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U. S. DEPARTMENT OF AGRICULTURE.

WEATHER BUREAU.

PROCEEDINGS

OF THE

CONVENTION OF WEATHER BUREAU OFFICIALS,

HELD AT

OMAHA, NEBR., OCTOBER 13–14, 1898.

Prepared under direction of WILLIS L. MOORE, Chief U. S. Weather Bureau.

Edited by JAMES BERRY,
Chief of Climate and Crop Division, Secretary of the Convention.

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WEATHER BUREAU.
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Weather Bureau,
Washington, D. C., January 9, 1899.

Hon. James Wilson,
Secretary of Agriculture, Washington, D. C.

Sir: I have the honor to transmit herewith report of the proceedings of the Convention of Weather Bureau officials held at Omaha, Nebr., October 13–14, 1898, and recommend its publication as a bulletin of the Weather Bureau, the edition to be 5,000 copies.

Occasional conventions of Weather Bureau officials are regarded as very important, as they afford opportunity for exchange of views, discussion of methods, and means for advancing Weather Bureau work.

Conventions have been held in former years, but heretofore the subjects discussed have been restricted to the Climate and Crop feature of the service. The deliberations of the Convention of 1898, however, were of wider scope, covering practically the entire range of work of the Bureau, and the attendance was more than double that of any previous meeting.

The accompanying report contains many papers of exceptional merit that will prove of interest and value to the employees of the Bureau, as well as to its large corps of voluntary observers, forecast displaymen, and climate and crop reporters.

Very respectfully,

Willis L. Moore,
Chief U. S. Weather Bureau.

Approved:
James Wilson
Secretary.

CONVENTION OF WEATHER BUREAU OFFICIALS.

The beneficial results following the numerous conventions of State Weather Service Directors held in former years were so pronounced as to convince the Secretary of Agriculture that such gatherings should not only be held at stated intervals, but that those participating therein should not be restricted to officials engaged in any special line of work, as had been the case with the American Association of State Weather Services. He therefore decided that the scope of such conventions should be so extended as to cover a wider range of service, and that the regular station officials, as well as those in charge of Climate and Crop Service centers, should have the privilege of taking part in the proceedings and profiting by the experience to be gained by future conferences of this character. Accordingly on April 5, 1898, the Chief of the Weather Bureau announced that a convention of Weather Bureau officials would be held at Omaha, Nebr., probably in July or August, 1898, and that the proposed convention would meet in place of the American Association of State Weather Services. The hope was expressed that every section director and local forecast official would be present, and that as many regular station officials and assistants as could do so would attend. This announcement was received with general favor, several from the Central Office, and nearly all of the prominent station officials expressing their intention to be present.

Brief papers on topics of interest to the Bureau, both in its practical work and upon scientific subjects, were invited, and the many valuable and interesting contributions which form a part of this report show how ready the employees of the Bureau are to respond when called upon to write upon such topics.

In the announcement of April 5 it was not possible to fix the date of the meeting, but at that time it was expected that it would be called about midsummer. Later, however, it was deemed advisable to postpone the meeting until after the close of the crop season. It was not until September 15, that October 12 and 13 were determined on as the dates of the meeting, but the uncertainty as to the time of the Convention in no way interfered with making such preliminary arrangements as were necessary, nor did it tend to decrease interest in the Convention on the part of the officials of the Bureau.

By October 1 nearly seventy Weather Bureau officials had made arrangements to be present at the Convention, authority to attend

having been granted upon condition that station duties would be performed without additional expense to the Bureau during the period of their absence, and that the journey from their respective stations to Omaha and return should be made without cost to the Bureau for transportation, personal or other expenses. That so large a number of officials should attend the Convention under these unavoidably hard conditions, is a matter which forcibly illustrates their zeal and their fidelity to the great work on which they are engaged.

The Commercial Club of Omaha kindly placed its elegant rooms in the Board of Trade Building at the disposal of the Convention, and a number of hotels conceded special rates to its members.

The Chief of Bureau appointed as executive committee to arrange such details as are incident to gatherings of this character, the following: I. M. Cline, M. D., Galveston, Tex., Chairman; Prof. Cleveland Abbe, Washington, D. C.; H. C. Bate, Nashville, Tenn.; James Berry, Washington, D. C.; F. H. Brandenburg, Denver, Colo.; J. Warren Smith, Columbus, Ohio; T. F. Townsend, Philadelphia, Pa.

As the officers of the Transmississippi and International Exposition had planned to conduct peace jubilee exercises on October 12, which were participated in by the President of the United States, members of his Cabinet, officers of the Army and Navy, and other high civil officials, among whom was the Chief of the Weather Bureau, who was to open and preside over the Convention, it finally became necessary to defer the meeting until October 13, which necessitated a continuance of its sessions on the 14th.

The various States and the District of Columbia were represented by the officials of the Bureau as follows:

Alabama.—F. P. Chaffee, Montgomery.
Arkansas.—E. B. Richards, Little Rock; Wayland Bailey, Fort Smith.
California.—W. H. Hammon, San Francisco; G. E. Franklin, Los Angeles.
Colorado.—F. H. Brandenburg, Denver; J. P. Slaughter, Pueblo.
District of Columbia.—Prof. Willis L. Moore, Prof. Cleveland Abbe, Prof. H. A. Hazen, James Berry, E. B. Calvert.
Florida.—A. J. Mitchell, Jacksonville.
Georgia.—J. B. Marbury, Atlanta.
Illinois.—H. J. Cox, Chicago; C. E. Linney, Chicago; John Craig, Springfield; P. H. Smyth, Cairo.
Indiana.—C. F. R. Wappenhans, Indianapolis.
Iowa.—J. R. Sage, Des Moines; G. M. Chappel, Des Moines; E. H. Bowie, Dubuque; U. G. Pursell, Sioux City; J. M. Sherier, Davenport.
Kansas.—T. B. Jennings, Topeka; G. H. Noyes, Topeka; G. T. Todd, Dodge.
Kentucky.—G. E. Hunt, Louisville.
Louisiana.—A. G. McAdie, New Orleans,
Maryland.—F. J. Walz, Baltimore.
Massachusetts.—John W. Smith, Boston.
Michigan.—C. F. Schneider, Lansing; N. B. Conger, Detroit.
Minnesota.—T. S. Outram, Minneapolis; P. F. Lyons, St. Paul.
Missouri.—R. J. Hyatt, St. Louis; A. E. Hackett, Columbia; R. L. Anderson, Hannibal.
Montana.—E. J. Glass, Helena.
Nebraska.—L. A. Welsh, Omaha; J. H. Spencer, Lincoln; J. C. Piercy, North Platte.
New Jersey.—E. W. McGann, New Brunswick.

New York.—D. Cuthbertson, Buffalo; A. F. Sims, Albany; R. G. Allen, Ithaca.
North Dakota.—B. H. Bronson, Bismarck.
Ohio.—E. A. Beals, Cleveland; J. Warren Smith, Columbus; G. Hass-Hagen, Toledo.
Oregon.—B. S. Pague, Portland.
Pennsylvania.—T. F. Townsend, Philadelphia.
South Carolina.—J. W. Bauer, Columbia.
South Dakota.—S. W. Glenn, Huron; G. B. Wurtz, Pierre.
Tennessee.—H. C. Bate, Nashville; L. M. Pindell, Chattanooga; S. C. Emery, Memphis; W. M. Fulton, Knoxville.
Texas.—I. M. Cline, Galveston; H. H. Curley, San Antonio.
Washington.—G. N. Salisbury, Seattle.
Wisconsin.—W. M. Wilson, Milwaukee.
Wyoming.—W. S. Palmer, Cheyenne.

The Climate and Crop Sections were represented by voluntary observers from a number of States, as follows:

California.—N. W. Blanchard, Santa Paula.
Colorado.—P. H. Boothroyd, Waterdale; E. S. Turner, Julesburg.
Illinois.—C. N. Butt, Knoxville.
Iowa.—E. W. Calwell, Sioux City.
Kansas.—M. B. Light, Winfield; Martin Musil, Ellenwood.
Missouri.—A. J. Sharp, Harrisonville.
Montana.—M. H. Pierce, Plains.
Nebraska.—H. F. Bethune, Lincoln.
New York.—Dr. John W. Kales, Franklinville; D. M. Kinne, Hoyts Corners; J. Knappenburg, Mount Morris.
Oregon.—B. E. Dosch.
South Dakota.—G. A. Perle, Flandreau; Frank Williams, Centerville.

The Convention was placed under great obligations to Mr. R. M. Reese, stenographer to the Honorable Secretary of Agriculture, for his most valuable and efficient services in reporting its proceedings.

Owing to limited time it was not possible to read at the Convention all the papers presented, but most of them were read in part and are given in this report, either in full or in part, as seemed most proper. After the opening address by Prof. Willis L. Moore, Chief of Weather Bureau, the following program was taken up:

1. Relation between the Weather Bureau and the public.—F. J. Walz, Baltimore, Md.; G. N. Salisbury, Seattle, Wash.
2. Forecasts and special warnings:
   (*a*) Forecasts best calculated to aid maritime interests of the Great Lakes; method of reaching those interested.—H. J. Cox, Chicago, Ill.; N. B. Conger, Detroit, Mich.
   (*b*) Are the present warnings and displays by flag and lantern the best that can be devised for the Atlantic and Gulf coasts?—John W. Smith, Boston, Mass.; Alex. G. McAdie, New Orleans, La.
   (*c*) Possibility of giving warnings of northers, cold waves, and heavy snows to stock raising interests forty-eight hours in advance.—F. H. Brandenburg, Denver, Colo.; E. J. Glass, Helena, Mont.
   (*d*) Warnings of washouts, floods, cold waves, and heavy snowfalls for the benefit of transportation companies.—J. Warren Smith, Columbus, Ohio; T. S. Outram, Minneapolis, Minn.
   (*e*) What classes are most benefited by the forecasts? Are they just what are needed? Are they properly disseminated and utilized?—J. R. Sage, Des Moines, Iowa; H. C. Bate, Nashville, Tenn.
   (*f*) Long range forecasts: Can they be made with sufficient precision to be of general utility?—Prof. H. A. Hazen, Washington, D. C.; Patrick Connor, Kansas City, Mo.; B. S. Pague, Portland, Oreg.
   (*g*) Forecast distribution: Should the wording of the forecasts be confined to the vocabulary of the present logotype outfit? Is it advisable to extend

the vocabulary of the logotype outfit?—F. P. Chaffee, Montgomery, Ala.; G. M. Chappel, Des Moines, Iowa.

(*h*) River and flood service.—R. J. Hyatt, St. Louis, Mo.; L. M. Pindell, Chattanooga, Tenn.

(*i*) Should warning messages (Form 1043 C) be of some distinctive color to more readily attract attention?—S. W. Glenn, Huron, S. Dak.; T. B. Jennings, Topeka, Kans.

3. Paper: Relation of the Weather Bureau to the Department of Agriculture.—E. B. Calvert, Washington, D. C.

4. West Indian hurricane service.—Prof. Willis L. Moore, Washington, D. C.

5. Possibilities of the weather service on the Pacific coast. Value of Mount Tamalpais observations.—W. H. Hammon, San Francisco, Cal.; B. S. Pague, Portland, Oreg.

6. Paper: Some rain-producing processes.—Prof. E. B. Garriott, Washington, D. C.

7. Relations with the press, commercial bodies, and scientific organizations. How promoted.—E. A. Beals, Cleveland, Ohio; A. F. Sims, Albany, N. Y.

8. Meteorological statistics: How to improve them that they may meet the needs of the medical profession, hydraulic and sanitary engineers, promoters of irrigation projects, etc., and does the present monthly section report meet such needs?—W. M. Wilson, Milwaukee, Wis.; E. W. McGann, New Brunswick, N. J.

9. Paper: Some notes on agricultural meteorology, with special reference to the rainfall element.—Charles E. Linney, Chicago, Ill.

10. Effect of forest clearing and cultivation upon: First, water supply and soil; second, rainfall; third, temperature.—W. M. Fulton, Knoxville, Tenn.; Geo. N. Salisbury, Seattle, Wash.

11. Is the weather map appreciated and understood by the masses? Would not the postal card weather forecast prove a satisfactory substitute for the map, except where it is used for the purposes of study and instruction?—E. B. Calvert. Washington, D. C.; T. F. Townsend, Philadelphia, Pa.

12. Paper: Primary work on meteorology for the use of schools.—Patrick Connor, Kansas City, Mo.

13. Should not certain important Weather Bureau stations, the duties at which cover a wide range of work, be designated stations of instruction for newly appointed observers?—J. Warren Smith, Columbus, Ohio; C. F. R. Wappenhans, Indianapolis, Ind.

14. Climate and Crop Service, weekly bulletins: Should remarks of correspondents be published as supplementary to general discussion? Should weekly reports of temperature and rainfall be telegraphed to section centers from selected voluntary stations?—A. E. Hackett, Columbia, Mo.; J. B. Marbury, Atlanta, Ga.

15. Paper: Frost fighting.—Alex. G. McAdie, New Orleans, La.

16. Aerial observations.—J. C. Piercy, North Platte, Nebr.; G. B. Wurtz, Pierre, S. Dak.

17. Should not a book providing for permanent record of meteorological observations for prolonged periods be furnished for use of section centers and voluntary stations?—J. W. Bauer, Columbia, S. C.; G. A. Loveland, Lincoln, Nebr.

18. Paper: Atmospheric moisture and artificial heating.—W. M. Wilson, Milwaukee, Wis.

19. Should not a book be provided suitable for keeping record of the issue of instruments and flags to voluntary observers and displaymen?—R. G .Allen, Ithaca, N. Y.; B. H. Bronson, Bismarck, N. Dak.

20. Are changes in the present forms (1053 and 1054) for reporting weekly climate and crop conditions advisable?—Charles E. Linney, Chicago, Ill.; A. J. Mitchell, Jacksonville, Fla.

21. Should pay be allowed persons, not in the employ of the Bureau, while learning station duties to enable them to properly perform such duties in emergencies?—D. Cuthbertson, Buffalo, N. Y.; G. E. Franklin, Los Angeles, Cal.

22. Papers:

Professor Marvin's weighing rain and snow gauge.—W. W. Carlisle, Minneapolis, Minn.

Interchange of standard climatic data.—Alex. G. McAdie, New Orleans, La.

Studies of climate.—F. J. Walz, Baltimore, Md.

Voluntary stations, their object and collateral functions.—A. J. Mitchell, Jacksonville, Fla.

Snow and ice measurements.—Hermann Volker, St. Paul, Minn.

Benefits of the Weather Bureau to western Nebraska.—J. C. Piercy, North Platte, Nebr.

Development of the Weather Map.—E. B. Calvert, Washington, D. C.
Establishment and inspection of voluntary, river, and cotton belt stations.—J. B. Marbury, Atlanta, Ga.
Storm signals on the Great Lakes.—H. J. Cox, Chicago, Ill.
Long-range weather forecasts.—A. B. Crane, Pensacola, Fla.
The weather as a topic of conversation.—A. S. Brendle, Schaefferstown, Pa.
Distribution of forecasts by mail.—P. F. Lyons, St. Paul, Minn.
Utility of hygrometric observations.—A. Pennell, M. E., Kansas City, Mo.
Wind vanes.—C. P. Cronk, Cape Henry, Va.

OCTOBER 13, 1898: MORNING SESSION.

The Convention was called to order at 10 o'clock a. m., in the rooms of the Commercial Club of Omaha, by Prof. Willis L. Moore, Chief of the Weather Bureau, who said:

GENTLEMEN, OFFICIALS OF THE UNITED STATES WEATHER BUREAU: I am very glad to have the opportunity to welcome you here this morning; to welcome men who are not only interested in meteorological science, but in applying that science to the commerce and the industries of the United States. That they are willing to come here and give their time and pay their own expenses for the purpose of communicating one with the other—the State of Washington getting information from Florida, and New England from the great arid Southwest—shows that you have such heart in this work that you are willing to sacrifice your own personal interests to the public weal. I remember the first convention I attended; it was a number of years ago, when I was a section director. Afterwards, when I came to the control of the weather service, I found that the discussions which I had heard at Buffalo and Indianapolis had given me many useful ideas. Many of these you have since seen incorporated in the rules and regulations of this service. Now, we have met again, and our numbers are much greater than at any previous meeting. We meet under slightly different conditions—simply as Weather Bureau officials. Before, we met as representatives of State organizations, or as representatives of State organizations having cooperation with the Federal service. Such cooperation has in great measure been succeeded by the Federal Government taking complete control of what were the State services, although in a few cases there remains very valuable cooperation between the National service and the State services, as in New York, Iowa, New Mexico, California, Maryland, and Michigan.

I shall not take up your time this morning with a long address, for I know we have an extensive program. I feel, however, like taking advantage of the opportunity to discuss here a few family matters. Actions speak louder than words; therefore, I do not know that it is necessary for me to say much. I believe you all recognize the fact that to-day every man in this service, from the humblest to the most important official, stands purely and simply upon his own merits. I believe you realize that there has not been a

selection, a promotion, or a reduction in the Weather Bureau during the last several years that was not controlled absolutely and entirely by the merits of the man, without regard to extraneous influence, so far as the head of the service was able to judge. If an error has been made, it was simply an error of judgment. We are most fortunate in having had in a former Secretary of Agriculture a man who had our technical workers classified. We are still more fortunate in having for the present Secretary of Agriculture a man who, without exception, has demanded that every recommendation coming to him from the weather service shall be based entirely upon the merits of the man and the needs of the public service. We have a man at the head of the great Department of Agriculture whose innate kindness of heart is such as to warm every man's affections toward him. He has done much for the weather service; he has done more than any other man to raise the standard of its personnel. After several trips through the country, meeting with our local forecast officials, our section directors, and our observers, he came back and told me he was very much impressed with the character of the officials of the weather service, and it would give him pleasure to honor my recommendations for such reasonable advancement of these officials as the appropriations would allow him to make.

I wish to speak especially of one matter which I believe is important in maintaining a kindly yet thoroughly efficient discipline at your stations. I speak of this after extensive experience of my own, in control of some of the large stations, and especially since I have presided at the Central Office in Washington. It is this: Allow no man associated with you to come to you with tales of another, or to impeach in any measure the official integrity of his companions, unless you bring in the accused man also, and give him full opportunity to answer his accuser. Do this and you will find that the harmony and efficiency of your stations will be greatly improved. We desire to place every official, both at the Central Office and throughout the extensive ramifications of this service, in such position that he can feel that he may go on with his work without fear of his reputation or standing being assassinated. I especially call your attention to this feature. I do not know that it is necessary, because I feel that your discipline to-day is of a very high standard of excellence. And when I say discipline, I do not mean harsh treatment, or that rigid lines be drawn upon a man, but I mean such discipline as will encourage the pride of the man and the spirit of the official, and yet maintain the authority of the officer in charge. It is possible to have such discipline, and I believe we have it to-day. I can say further that there are no dissensions at the Central Office of the Weather Bureau. There is harmony there, and that means much to the rest of you.

I would encourage all to be students. I know that most of you are, and I know that many (myself included) have found the best years of their lives for study while in the weather service. The Central Office has outlined a course that we expect every new appointee to become proficient in before he is eligible for advancement. It is necessary, in writing your reports, that you express yourselves in good English. It is necessary that the local forecast official be well versed in physics and mathematics. It is necessary that the section director be thoroughly conversant with the processes under which plant life has its inception and makes its growth. We scrutinize carefully the qualifications of a man, his education, moral character, and the study he has made since entering the service, before we take him up for advancement.

Just one more matter. We have made many changes in the distribution of the salary fund. A few employees have lost thereby while many have gained. We have endeavored to so apportion the fund as to make the pay commensurate with the importance of the assignment and the merit of the official. I believe you are satisfied that there has been a determination at the Central Office to so reapportion that fund as to secure a more equitable distribution of the money than had obtained before.

I think it but proper to take advantage of this occasion to refer to an official, not now associated with us, who spent more than twenty-five of the best years of his life in the work of this Bureau. When hostilities with Spain began he returned to the Signal Corps of the Army, to which branch of the military service he belonged. I am sure you join me in wishing him a brilliant career. I allude to Col. H. H. C. Dunwoody.

Before proceeding to the consideration of the program, I would say that away back in 1870 there was one who is with us to-day, who laid the foundation of the present weather map, and who, by his own investigations and experimentations, compiled weather charts and made forecasts long before the Federal Government did so. That man has been connected with the Federal Weather Service from the very day of its beginning, and has been an important worker through its whole development. He is a man whom every one of you honors for his scientific attainments, and whom all who know him esteem for his courteous bearing and innate kindness of heart. I shall ask Prof. Cleveland Abbe from time to time to relieve me as presiding officer of this Convention.

Professor ABBE. Gentlemen, I think you all want to get down to business, and you don't want to hear from me. I have been writing a good deal the last five or six years in the Monthly Weather Review, and you know just what I would say if I were to say it all over

again. The Chief wants to get through with this long program. How he is going to do it, I don't know, but we will begin with paper No. 1.

TOPIC No. 1.—RELATION BETWEEN THE WEATHER BUREAU AND THE PUBLIC.

F. J. Walz, Baltimore, Md., and G. N. Salisbury, Seattle, Wash.

Mr. Walz. It embarrasses me somewhat to have the first paper on the program, especially as I am to immediately follow our eloquent and honored Chief in addressing you, and also because this is my first attempt at speaking to so large a body of my colaborers. I am still more embarrassed by the fact that while en route, the few notes I had made on the subject of this first topic were lost, and so I shall have to depend upon the inspiration of the moment, aided by the few notes I have since jotted down, and by your inspiring presence.

The topic is, The Relations Between the Weather Bureau and the Public. This subject is one practically without limits, were it proposed to discuss it in all its phases and features, for all our work is along this line. All mankind is affected by the weather in some of its phases, and it is the intent and purpose of the Weather Bureau to study out those phases and consider them in all their various aspects. Even if we take any one of several lines which might be suggested, it would take up the entire time of this Convention. The subject is one with which all the officials here assembled are daily confronted in the management of their stations; it is one of the most important subjects we have to deal with. The value and importance of each local office depends so largely upon the handling of these questions that one might say the prime object of this Convention is to consider the relations between the Weather Bureau and the public in some one or all of their phases. Nearly every paper that will be produced, and nearly every discussion of importance that is to be brought out, will be in the line of looking for some improvement in our relations with, and of giving more benefits from, the Bureau to the public. The propositions I shall suggest will bear more directly upon those subjects which have been made manifest in the management of local offices. In a general sense these relations might be considered under two heads—the direct relations we have with the public, and the indirect. And again we might classify the public under two heads, as the general public who want to look at a forecast to see what the weather will be to-morrow, and the commercial and maritime exchanges and organizations of that kind, upon whose dealings the weather has a direct effect, and this not only one day, but day after day, year in and year out. Under this latter head we might classify the relations we have with schools and various educational institutions. The direct kinds of relations, I might say, are those that exist between the personnel of the station and the public. The value of the mental, moral, and social qualities of the official in charge determines, to a very large extent, the value of a station to the public. The mental qualifications of the officials you will of course have to take for granted after having heard what our honored Chief has said;

and judging from his attitude toward the moral status of our stations, any agitation on that question would be rather superfluous. The social qualifications are of considerable importance. It is now within the power, as unfortunately it once was not, of every member of our body to become a representative man in his community, and he owes it to himself and the Bureau that he should not be satisfied with anything short of that. He should be a representative man, one who is looked up to, so that anything he may say will have weight attached to it because of his being a representative man.

Then, again, in our direct personal relations with the public, the location of the office is a very important matter. The office, as we all know, should be centrally located and easy of access to the public; it should be where the public can come into close contact with us, and where the men engaged in the interests to be served by us can visit the station and become more familiar with our work; the benefits to be obtained from this personal intercourse are almost incalculable. There should be frequent personal visits by the official in charge to the various organizations, maritime exchanges, boards of trade, etc., and they should know us and our work, and be interested in it, as indeed they are. The Weather Bureau official should be familiar with the needs of organizations of all kinds, and provide for them—not only their present needs, but by anticipating their wants. He should acquaint himself with the public school system; induce, as far as possible, an interest in the study of meteorology and meteorological subjects, elementary, it may be, but sufficient to enable every one of the rising generation to take an active interest in our Bureau, and be able to read a map intelligently and make his own deductions therefrom.

Indirect relations are maintained through the issue of our local publications, through the medium of the press, and through substations, voluntary observers, and the distribution of forecasts. The best methods to be followed in the issue of our publications, whether they are at present such as we want them to be, or whether they need modifications, will probably be discussed in papers that will follow. The local newspapers, however, as we all know, should be utiltzed to the fullest extent in the dissemination of whatever information we may have to give to the public, not only meteorological data, but information as to our plans for future extension of the benefits of the weather service. I think the newspapers should be advised of these matters in advance, so as to be able to tell the people of anticipated changes. The establishment of substations and the serving of outlying interests call for special study. Officials should be as alert to the needs of distant substations, and as desirous to serve them promptly and accurately, as they are to serve those with which they come more directly in contact. Some of us are at times liable to forget the Weather Bureau's benefits are not only for those we see immediately around us, but extend far out into the State, and over the whole of it. Every day there are people far distant from us, whom we have never seen, who are looking to us for information, not only forecasts, but for the other data we have to give. We should see to it that they obtain all the information possible to give them as to our work, which they desire, and which it is possible to give them.

All of these questions will be considered, and many of them dis-

cussed during the present meeting, as well as many points I have not mentioned. We have all had our experiences, all have our cherished plans and theories, and now is the time to bring these out and have them tested, and such as stand the test of this Convention should become common property for the benefit of all of us. But we must all remember that however admirable a plan we may have, its success will depend very largely upon the personality and energy of those to whom its consummation is entrusted. That will always be the important factor in the relations between the Weather Bureau and the public.

Mr. Salisbury. Faster and faster, more and more constantly, is the Weather Bureau and its work coming into public notice. More and more are the general public, even those of only ordinary education and intelligence, becoming quite familiar with what the Bureau does, and what it aims to do. And to-day, the modest Weather Bureau official is taking a better place among his fellow-men, and is looked upon with more confidence and respect than ever before. The foregoing are facts, for which there are good and sufficient reasons. As, since creation dawned, there never has been a time when there was no weather, so there, perhaps, has never been a time when there was not a weather prophet. Undoubtedly primitive men had their weather signs or prognostics; savage and barbaric people have in all known times had their "rain doctors;" more modern times and peoples have had their almanacs, which contained "long range" predictions; but only within a short time has meteorology become truly a science—only within half a life-time have there been organized weather bureaus, worthy of the name, for the benefit of the public. For a far longer time, to be sure, climatic records have been kept, which were very accurate, valuable, and useful, but an organization for keeping climatic records is not properly regarded as a weather bureau unless it foretells storms and weather changes.

What is the attitude of the public toward such an organization? We know how the superstitious savages have regarded their "rain doctor" with awe and amazement, not unmixed with fear or distrust. Should, unhappily, the doctor's false pretensions be exposed, woe to him. Our dethroned deities always suffer worse than common clay. Our almanac maker fared somewhat better. Credulous belief and wild wonder, or on the other hand, doubt or ridicule, were his portion. The prognostics by the moon, the sky, or animate nature, the blind guesses or absurd astronomical pretensions of the almanacs had so long held sway that the public scarcely knew how to take it when a Government service undertook to forecast storms and daily weather changes from laws so recently discovered that they were entirely unknown to the many. Some scoffed, some ridiculed, many wondered, all more or less doubted, for it was an experiment. To the uninitiated the Signal Service seemed a mystery, and indeed it was in some respects an enigma up to its last day. The curious public were, however, great investigators, and gradually the mystery lessened. It was seen that the Signal Service officials were even as other men, as far as their restrictions allowed them. Incited to read up on meteorology or weather and storm movements, becoming familiar with barometers and thermometers, the glamor of erudition that had encompassed the service became dim and shadowy. The

elaborate predictions that emanated from the chief office were seen to be deductions from general facts. The Government institution simply had at its disposal a vast electric telegraph system for instantly collecting a great number of those facts.

Though the ridicule in some instances remained, yet the general confidence grew; grew with every triumph scored by the Signal Service; grew when its storm-warnings saved hundreds of ships from peril and disaster; grew when its cold-wave warnings gave two to three days' notice of severe cold spells; grew with every successful flood warning or frost warning. The public became unsparing when marked failures occurred, with seemingly little excuse. It was generous, perhaps to a fault, where there was some excuse.

The Signal Service did a great work as all must admit, and no matter how we may view its military régime, it should never be forgotten that its officers and men worked out, in a great measure, the systems which make the weather service of this country unequaled, or even unapproached by any other. But, though doing a great work, it was not best adapted for that work, as we now well know. It had a military machinery which was supposed to greatly aid it, and by some was regarded as indispensable, but as a weather service it was sorely handicapped, for it carried ever on its shoulders (like Sinbad) a burden which would not be shaken off. The public was not *en rapport* with it; it was harrassed with a sense of exclusion; in short the military engine was not adapted to civilian work. The service and the public both realizing this full well, a simultaneous effort was made in its last days, though on opposing lines. From within its liberal minded officers strove to adapt its machinery to business purposes, and educate the public to its workings; from without the public sought to effect a transfer to a civil department. Happily the latter effort was successful. Since its organization as a civil bureau, under an appropriate department, the most liberal policy has prevailed, and every effort has been made to improve its methods, perfect its workings, and make it of the utmost possible benefit to all trades, all professions, all classes.

Hence, as officials, it may greatly profit us to consider at times how the Bureau now stands in the estimation of the public, and to reflect on these questions: What are we doing for the people; how are we doing it; is it of benefit to them; what is the popular verdict?

It is safe to attempt to reach the public expectation, for that is now high. Only sometimes it expects impossibilities. For instance, to expect to receive a forecast for a date a week ahead, or even two days, often is unreasonable at the present stage. "There may come a time," but the time is not yet. To expect to know just the hour it will begin raining is to demand a little too much; likewise, just when it will stop; just how cold it will get, and how long it will remain so.

But the public rightly expects accuracy, so far as the information goes. Inaccurate information is worse than none. It is much better to say "We do not know," however humiliating the confession, than to predict what will not come to pass. If we do not know, with considerable certainty, what the weather will be two or more days in advance its prediction should not be attempted. It savors of charlatanism; it begets lack of confidence in us; our information becomes unreliable, and whom can we blame save ourselves, if we

suffer the odium or oblivion assigned to all false prophets? The aim of the Bureau should be to foster public confidence. It should always be sure of its ground. Even the humblest officials should ever remember, and the more prominent ones should never forget, that each correct statement and each accurate prediction adds to the grandeur and beauty of its temple of reputation; while every misstatement, and every gross failure, is a stone taken from its foundation, lessening the stability and threatening the overthrow of the structure.

"England expects every man to do his duty" signaled a gread admiral at the beginning of a great battle. Our service and an indulgent but just public expect this of us. The commercial and scientific bodies, representative men, have always treated the local officials with every consideration due to men of culture and intelligence. In so doing, while honoring the Government Bureau, they reflect credit on themselves. We should never prove unworthy of it.

The general public, all classes and conditions, meet in our offices every day. We give them all kinds of information, always cheerfully and courteously let us hope, and they appreciate it, or ought to. Our information must be exact, and given clearly, in such a manner as to inspire confidence, if we wish it to do good. They have the right to expect it of us. They may not have the right to annoy or bore us, but should some do so it would hardly be advisable to tell them of it.

In its relation to maritime interests the Weather Bureau has one of the greatest responsibilities. True, calamitous storms causing disaster to shipping are infrequent, but it is necessary to tell just when storms will be violent. In consequence of stormwinds being so uncertain it is sometimes thought necessary to warn of all storms in order that the violent ones may not be overlooked; therefore, business interests are often put on the lookout for severe storms which do not materialize and a loss of confidence results, the natural inference being that the warnings were mere guess work and need not again receive serious attention. This is a grave mistake on the part of the affected interests, and a fatal day comes when it is seen and bitterly rued. How can greater confidence be engendered, or rather how can loss of confidence be prevented? Manifestly by accurate diagnosis on the part of officials, so that distinction will be made between slight and dangerous storms. This is very difficult and leaves the possibility of a storm proving more violent than appearances indicated. It may be that eternal vigilance is the price of security, as of liberty, but it is impossible to keep the interest up to a high pitch all the time by constantly sounding the warning of danger when no danger appears. And yet there are times in certain localities when storms follow in such rapid succession that to give warning of all requires an almost constant signal. Therefore, I believe it imperative that a method to distinguish between the approach of a harmless storm and a disastrous one be found. Often the fault is with the conditions, rather than with the service. Ships should be built to withstand the fiercest gales; anchor chains should hold against the greatest possible strains; wharves should be strong enough to endure the heaviest waves; dike and sea walls should be high and thick enough to turn aside the highest hurricane tides. But in this day and generation the ordinary is built for and not the ex-

traordinary. Take the case of Savannah, Charleston, and other cities of our south Atlantic coast. Every three to five years disastrous West India hurricanes approach them, causing widespread destruction and loss of life; yet what steps are taken to provide more secure anchorage, to erect stronger structures, to provide dikes and sea walls for the tideswept islands? Here the communities are plainly at fault, and not the bureau. If everything was kept strong and secure, then, as I have suggested, the minor storms might safely be neglected.

There is no doubt that the agricultural class is now coming into close relation with our Bureau, and that in certain branches of agriculture considerable benefit is derived from our work. The writer has ever held the opinion that the greatest benefit of the weather service to agriculture would be in a climatic way; ascertaining what portions of the country could be successfully cultivated. In collecting this climatic record the voluntary service is doing a great work, stupendous in magnitude and far-reaching in results. It is establishing a climatic history and character for each locality that will be a guide to all future generations. Its value to the general government in thus indicating the capabilities and limitations of those localities will be beyond price. Yet it is obtained at very little expense so far as concerns the voluntary observer. It is possible that the daily forecasts, now of value to certain classes of farming, can be so extended or their distribution so improved as to reach many more classes. It is a fair conclusion, however, and there are many who hold it, that a large portion of farmers will continue to farm according to their lights and not according to the advice of the Government Weather Bureau; this, too, while not denying that the successful cranberry grower of Wisconsin is the one who relies on the prediction to warn him of frost and the successful raisin grower of California is he who heeds the Bureau's rain warnings.

The press is and must ever be the medium through which the greatest amount of our information reaches the public. Consequently, it behooves us, as officials, always to be on good terms with the editors and reporters. Most of us are, though at times it requires considerable tact to steer clear of dissension and much patience under frequent nagging and senseless though not ill-meant witticisms. Some papers will persist in being cold, if not secretly unfriendly. The local official should carefully win them over. Nothing is ever made by antagonizing a newspaper, and much may be gained through its friendship, not only by the official, but much more by the service he represents.

In regard to the possible future of the Bureau, we can not lift the veil, but can only see dimly through it, as we judge the future by the past. Who, thirty years ago, would have thought the present development of the Weather Bureau possible? Did the public realize what value its records, its daily forecasts, its storm warnings would prove to be? Assuredly not. So we can not set a limit to the possibilities of the service for usefulness. It is covering a wide field, but not too wide. Year by year the experience and knowledge of former years is built upon, and future research and discoveries will most surely add vastly to our present knowledge of meteorology and our usefulness to the public.

Professor Moore. Mr. Salisbury has spoken of the Signal Corps. I had some conversation with General Greely yesterday, and he asked me especially to present his compliments to this Convention. I was anxious that he should be here and speak to you, but he said that he appreciated the fact that we would be glad to have him here, and he would be here if he had not made engagements that would prevent him from attending. I want to say to you that in the closing hours of the last Congress there was repealed that part of our organic law which permitted the Chief Signal Officer, in addition to his military duties, to take charge of the Weather Bureau, and likewise appoint four army officers to act as assistants. Now the repeal of that law was favored by General Greely, the man directly interested. In appearing before the Senate committee I held in my hand a letter from General Greely, saying that the weather service had demonstrated its ability to handle this extensive public service under a civil administration, and that it was time the Bureau was relieved from the possibility of army control; that he believed the Signal Corps, of which he was Cihef, would be better off in confining itself to its purely military functions; that his officers would know where they were to make their records; that his bureau would derive benefit from confining itself purely to its military work, and the Weather Bureau would receive equal benefit by having its perpetuity under civil control assured to it. We are under obligations to Gen. A. W. Greely, than whom no abler Chief ever presided over the weather service, for his manly and magnanimous action.

Mr. McAdie. In view of what the Chief has said, I think it would be a graceful thing to send a greeting to the Signal Corps, United States Army, and General Greely, its chief, expressing our admiration and appreciation of the splendid work done by that corps under his command during the war. We are proud, I think, of our old corps. I, therefore, move the following resolution:

Resolved, That the Weather Bureau officials, in convention assembled, express their appreciation and admiration of the excellent work done by the Signal Corps, United States Army, during the late war.

This was adopted unanimously by a rising vote, and the Secretary directed to forward a copy to the Chief Signal Officer, United States Army.

Professor Moore. In Mr. Walz's paper I notice he referred to the personal character of the man—his moral character and social standing as a representative of the Weather Bureau. He passed it rather lightly, but it is an important matter. We have made it the subject of inquiry whenever selecting section directors or local forecast officials, and I mention it now because our right to make such inquiry has been questioned; it was several times questioned whether we had the right

to inquire into the moral character, the domestic and personal relations of a man, before selecting him for an important trust. I believe we have that right, and I believe we shall always assume the right to make such inquiries regarding a man. Not only must he be an able official, if he is selected for an important trust, but his private character, his moral and domestic relations, must be clean. (Applause.)

TOPIC No. 2.—FORECASTS AND SPECIAL WARNINGS.

(*a*) *Forecasts best calculated to aid maritime interests of the Great Lakes; method of reaching those interested.*

H. J. Cox, Chicago, Ill., and N. B. Conger, Detroit, Mich.

Mr. Cox being indisposed, his paper was read by Mr. Palmer, of Cheyenne, Wyo., as follows:

Not long ago masters of vessels on the Great Lakes pretended to disregard the forecasts and storm warnings of the Weather Bureau. Gradually the wants of the merchant marine have been more clearly made known, and efforts have been made to render the forecasts of the greatest practical value. At the opening of navigation last spring the plan of sending daily forecasts of wind and weather to all lake ports was adopted. This new service, together with the issue of the monthly lake marine meteorological charts and the work incidental thereto, comprise the greatest improvements during the past year. It is my opinion that lake forecasts should have special reference to the 24-hour period, and should be extended further only when, in the opinion of the forecaster, they can be made with a fair degree of accuracy.

The knowledge of the probable force and direction of the wind is of greatest importance to owners, navigators, and shippers, and also whether the weather is going to be thick with rain, sleet, snow, or fog, particularly the latter two. While the occurrence of fog may be expected under certain typical conditions, it also occurs under other and different conditions which are not understood. On this account, forecasts of fog have been rarely attempted, but it is possible that through the investigation now going on information may be secured which will lead to successful forecasts of the foggy condition that is so dangerous to shipping interests. During the prevalence of fog sailors may proceed with a fair expectation of avoiding accidents while "in the open," but progress through channels is always attended with the greatest danger. While daily forecasts are of great value, ample warnings of severe storms must be given in order that measures may be taken to prevent loss of life and property. The velocity of wind in a gale does not in itself show the real danger to navigation in any particular locality. In every case *the direction* is a most important factor. Along the south shores of Lakes Superior and Erie and at the southern ends of Lakes Michigan and Huron a northerly wind of 35 miles after four or five hours duration prohibits navigation, while a 45 or 50 mile wind from the south causes no interference whatever. During the southerly gales of September 21, 1893, when the wind

attained a velocity of 60 miles per hour at Marquette, Mich., shipping along southern Superior suffered no inconvenience, although a 25-mile wind from the north after a few hours often stirs up such a sea as to force vessels like the *Northwest* and *Northland* to seek shelter in some one of Lake Superior's harbors. In fact, it is probably the effect of the sea rather than the direct effect of the wind itself which causes so much trouble. A captain can proceed along the leeward shore in absolute safety, when it would often be impossible for him to make any headway on the opposite side of the lake. Consequently, in issuing storm warnings for different points the probable direction of the wind should be taken into consideration in every case and no storm warning should be sent to any place unless the expected high velocity and direction represent a wind actually dangerous to navigation in that locality. The weather information can be distributed to the shipping interest by means of the press, telephone, telegraph, weather map, storm-warning bulletin, storm signal, marine reporter, and lake marine mail. While the telegraph must be used by the forecast center in notifying displaymen, the most rapid and effective mode of local distribution is by the telephone. Through that agency the Chicago weather office is often able to disseminate a storm-warning message to more than one hundred points in the city within a few minutes.

Mr. Conger. The subject which has been assigned me at this time is one that requires much thought. Constant attention to the marine interests of the Great Lakes alone will enable us to arrive at a satisfactory conclusion as to the best solution of our problems. In order to make our meaning more plain we shall be compelled to delve into ancient facts and recent history, and show the immense importance of the traffic on these inland seas. I trust you will bear with me in the somewhat dry figures that will be used to indicate the value of the shipping and the number of lives that the vessels carry, all dependent on the careful watchfulness of the Weather Bureau.

There are many at this Convention who probably are not familiar with the shipping of the Great Lakes or with the class of tonnage that floats on the broad bosom of these mighty fresh water oceans. For your information it may be stated that more tonnage passes the port of Detroit annually than the combined tonnage of our Atlantic, Gulf, and Pacific coasts. There are passenger steamers plying on these waters finer in their equipment than any ocean steamer afloat at the present time. These particular steamers are exclusively for passenger traffic, and do not carry a pound of freight during the season they are in commission. We may call attention to the steamer *Christopher Columbus*, the great whaleback passenger steamer, the like of which floats on no other body of water. It may be stated that during the busy season of the year an average of 100 vessels pass Detroit every twenty-four hours, or one every fourteen minutes; for twelve hours there have been 84 recorded passages, and for one hour a maximum number of 57, making the average nearly one every minute.

Of the large freight boats now plying on the Great Lakes, two representative fleets may be mentioned: The Pickands, Mather Company's fleet of fifty-one vessels, which is the largest fleet handled by an individual firm, and the Bessemer Steamship Company's fleet,

which represents the best type of the largest freight boats floating on the lakes at the present time.

The Pickands, Mather Company's fleet consists of 21 steamers and 30 barges, which are used principally to carry iron ore from the head of Lake Superior to either Lake Michigan or Lake Erie ports.

If this entire fleet were placed bow to stern it would make a line of vessels 3 miles long, and if loaded with ore would carry at one time 184,300 tons; the valuation of the vessels and cargo would amount to nearly $7,200,000; this immense cargo, if loaded on ore cars for shipment to the smelting furnaces, would require 6,143 cars and would make a train 42 miles long. It takes 572 persons to make up the crews of this fleet.

The Bessemer fleet contains among its vessels the largest steamers and the largest barges, and is representative of the higher class of freighters at the present time. The steamer *Samuel F. B. Morse*, launched this season, is 476 feet over all, 50 feet beam and 30 feet deep. Her capacity on 17 feet mean draft is 6,000 gross tons of iron ore, 225,000 bushels of wheat, or 430,000 bushels of oats. She has quadruple engines of 2,700 horse power. On a recent trip with a slow running wheel she made 14½ miles per hour light, and 13½ miles loaded. With a fast running wheel she is expected to make 17 miles per hour light. She has four Scotch boilers 13½ feet in diameter.

The barges *John A. Roebling* and *John Fritz* are twin ships. They are each 456 feet long over all, 50 feet beam and 29 feet deep. Their capacity is 7,000 gross tons of iron ore on 17 feet mean draft, or 260,000 bushels of wheat or about one-half million bushels of oats. It should be stated in connection with the *S. F. B. Morse* that she was intended to tow the *Roebling* and possibly the *Fritz* also, so that these three boats would move 20,000 gross tons of ore and nearly three-quarters of a million bushels of wheat and a million and a half bushels of oats. There are in this fleet 21 ships in all, 17 of which have a capacity of upward of 5,000 gross tons. The 21 ships will carry about 105,000 gross tons per trip. With fair dispatch twenty trips per season can be made, loading only one way, carrying somewhat more than 2,000,000 gross tons. Loading both ways they will carry about three and a quarter to three and one-half millions gross tons, or upward of 70,000,000 bushels of wheat in a season. Allowing 20 bushels of wheat to the acre this fleet would carry the product of 3,500,000 acres of land and would supply every man, woman, and child in the United States with a bushel of wheat. The crews average 24 to 25 men each. The cost of this great fleet was about $4,000,000, and it will carry between $5,000,000 and $6,000,000 worth of ore during one season, loading only one way.

When the Signal Service was first organized in 1871, the class of tonnage was very much smaller, in fact up to 1874, according to Beeson's guide of vessels now afloat, there was not a single vessel that would register 1,000 tons, and only one between 1874 and 1880 that registered over 1,000. The great increase in size of vessels began about 1887, and this increase has continued until the present year when the maximum was reached in the construction of the *S. F. B. Morse*, the *Roebling*, and *Fritz*.

The large tonnage floating on these great bodies of water requires to be well looked after by the Bureau, which is by law assigned to this particular work; and therefore I desire to call attention to certain

points which have impressed themselves on me during my experience on these lakes.

The forecasts best calculated to aid maritime interests on the Great Lakes are those which give the latest information about storm movements, and must issue from experienced forecast officials, who thoroughly understand the conditions they are endeavoring to meet. It is important for the forecast official to know the localities for which he is issuing the warnings, in order that they may be of the most service to them. For instance, high south winds are not dangerous on the south shore of Lake Superior, but it is next to impossible to put this information where it will be of service to the navigators who are on the fairway between Whitefish and Keweenaw points. Vessels leaving Marquette with a south gale simply keep along shore and in comparatively smooth water. The reverse is serious, as northerly gales cause damage along the entire southern shore of this lake. Again, on Lake Erie, southerly gales—that is, from the southeast or south—are of no serious import, but when the wind shifts to the southwest, then trouble begins and masters are on the lookout. South-shore Lake Erie ports are easily entered with south winds, but with southwest to north winds it is difficult to make an entry into these harbors, as most of them have narrow openings between piers to the inner harbor. For this reason southeast signals should not be displayed on Lake Erie, but an advisory message should be sent instead. In the record of twenty-six years and of over sixty-five southeast signals ordered at Detroit, only five have been verified by high southeast winds. Now, on the east end of Lake Ontario the southeast signal has great importance, as tow barges leaving the St. Lawrence River for Oswego encounter very heavy seas from southeast gales, and in consequence are obliged to lay to at Cape Vincent.

Southeast gales are not so serious on Lake Huron as are those from a northerly direction. Brisk northerly winds for some hours will cause more vessels to seek shelter on the southern end of the lake than a heavy southwest gale. One point in the displaying of signals I would desire to impress on all who have occasion to forecast for the lakes, and that is, an easterly signal should not be displayed when it is anticipated that the wind will shift to the westerly before the expiration of the time limit. I mean that a southeast signal should not be displayed when it is expected that the wind will shift to the southwest or west before the expiration of the 24-hour period. In using the terms "easterly" and "westerly" signals, I mean northeast to southeast for "easterly" and southwest to northwest for "westerly." On all the lakes the shift of the wind from east to west quadrants is of great importance, and it should be the object of the forecast official to anticipate this change. The forecast official has in his hands the power to anticipate these changes, which are of great importance to the maritime interests of the Great Lakes. He can call for special observations whenever, in his judgment, they are needed. When a storm is advancing across the lakes, these special observations are vitally important in assisting to anticipate the wind changes, and I believe it good policy to make free use of the telegraph during the time signals are displayed. It would be much more effective to hoist a southwest storm signal instead of southeast should it be apparent that the wind will shift to the southwest before the expiration of the time period. That the gale will set

in first from the southeast and then shift to the southwest should be incorporated in the message ordering the signal. It is the duty of the forecast official to anticipate the shift of wind, and not wait until the shift has arrived and then change the signal. Masters of vessels have commented on this delinquency on the part of the Bureau, and in doing so indicate that the Bureau is slow to act.

During the time period the forecast official should be allowed to change the signal from one direction to another, and this change should not affect his verifications. The changing of the signal from northeast to northwest should not affect the northeast order if the verifying velocity come after the change was made and before the expiration of the time limit.

Signals should be changed from one direction to another as necessity requires, and as indicated by the storm movement. It is not favorable to the Bureau to have easterly signals flying while a westerly storm is in progress, and this is one of the most important points I wish to make.

The Bureau should furnish the master with the latest information it has, and allow him the privilege of sailing his ships as best he may, using the information furnished by the Bureau as his best judgment dictates. A gale of 40 miles may be just what one master desires to assist him on his course, while another, going in the opposite direction, must lay to, awaiting better conditions. It is enough for the Bureau to accomplish to have placed within the reach of masters the opinions of our careful and experienced forecast officials. The masters will heed the warnings and sail their vessels so as to subserve their individual interests. It is our part to have the very best and latest information of storm movements, and see that it is promptly placed where the masters can have access to it; it is the part of the master to use this information so as to promote the interests of those he is serving.

The shifting of the wind during a storm period is a matter of vital importance to all mariners and should be especially looked to in making forecasts and ordering signals. When this point is well grounded, and the signals are changed promptly, I am of the opinion that the forecasts of to-day are well suited to the needs of the marine interests.

Advisory telegrams should replace signals where the winds are not of sufficient importance to warrant display; the methods of distribution are so systematic at the present time that no interest will be neglected by so doing. One decided improvement made in the past year is the displaying of signals only for important storms, and the use of the advisory message for warnings during the passage of minor storms or those which cause local disturbances only. This has been commented on very favorably by the mariners, and in consequence more attention is paid to the display of signals. The signals are now only displayed for important storms, and no important storm has passed over the Lake region during this period for which signals were not displayed in advance.

In speaking of local needs it should be taken into consideration that vessels sailing between Buffalo and Detroit have no means of obtaining information from the Bureau if they keep on their regular course. This is an argument for the discontinuance of the southeast signal on the south shore of the lake, as all harbors on the south

shore can be entered with safety during south or southeast winds, but not during the southwest, west, or northerly winds.

METHODS OF DISTRIBUTING FORECASTS AND STORM WARNINGS.

A forecast of the wind direction and force is sent to each wind signal display station on the lakes daily; the forecasts for all the lakes are sent to the regular stations; the forecasts for the upper Lakes issue from Chicago, and those for the lower Lakes (Erie and Ontario) from Washington.

These forecasts are posted in all the prominent places where shipping interests demand them. At the wind-signal display stations the masters of vessels lying in port are furnished with a copy of the daily forecasts and of all storm warnings.

The improvement in the distribution of the daily forecasts and storm warnings has been very marked during the past year; in the past three years more progress has been made in the matter of furnishing promptly the information of the Bureau to the masters than in the entire history of the service prior to 1895. When it is considered that, with one or two exceptions, the masters of steamers are in daily communication with the Bureau and are furnished with the latest information, it may be understood how far reaching and systematic is the present method of distribution of the daily forecasts and storm warnings. Let us, for illustration, consider a steamer going from Buffalo to Duluth. Before she leaves port, the master finds in his home office a copy of the forecasts for the next thirty-six hours and timely warnings of approaching storms. As he passes Detroit a weather map is placed in his hands by the excellent marine postal service at that point, and if a storm signal is flying, a copy of the warning message; should it be at night, in addition to the above, he is supplied with a copy of the p. m. report, giving the direction and force of wind at all lake stations. On his way up the St. Clair River it may be that an important storm warning has been issued; therefore, as he passes Port Huron, the marine reporter there hands him a copy of this warning. He passes up the lake, and the next day reaches the Sault; there he finds a weather map at the window of the office where he hands in his report to the officials of the canal, and very likely he meets our representative on the locks, who gives him the latest information and at the same time adjusts his barometer. After he leaves the Sault and until he reaches Duluth, a space of thirty-six to forty hours, he is without direct information from the Bureau, but he has the benefit of the display of signals at Whitefish Point, Deer Park, or Eagle Harbor, and when he again reaches Duluth finds the weather maps and storm warnings placed conveniently at his hand. Again, should he be sailing for Chicago, he is met by our displayman at the Straits of Mackinac and given a copy of the forecasts or storm warnings. At important points along his entire path are situated special wind-signal display stations, where storm signals are displayed, which indicate the direction and force of the wind, so that the safeguards of the Bureau are constantly within his reach. If he is at one of the display stations and desires later information than the displayman has, it is his privilege to telegraph for it at the expense of the Government either to Buffalo or Chicago. Even should he be in port where there is no Weather

Bureau station still he can telegraph for this information and it will not cost him a penny. The only requirement of the Bureau is that he shall give other masters in the harbor the benefit of the information which has been freely given him. Can anything be more complete than this for the protection of the mariner on the lakes? Is it possible to throw around him further safeguards than the Weather Bureau is now doing?

It is not necessary to go into details relative to the distribution of the forecasts and storm warnings at our regular stations, as it is well known that these are posted in all prominent places, and when storm warnings are issued or the conditions of weather are unfavorable the telephone and telegraph are used freely to spread the information broadcast. It is different with our displaymen. We employ men at the different points where our wind-signal stations are located to display the signals and to render the regular monthly reports during the season of navigation. These men post copies of the warnings in their offices and display the signals and answer such questions as may be asked by masters who visit their offices. But these men have other business to attend to; the amount of salary paid them for the display of signals is not large. However, I have found them to be ready and willing to assist so far as possible in improving the means of distributing the forecasts and storm warnings. The daily forecasts for the Lakes were first issued during last fall. At the opening of navigation in the spring copies of these forecasts were sent to all the wind-signal displaymen, with instructions to post them at two or tbree important points. This was done, yet it was found that the method of distributing these forecasts could be still further improved, and the logotype system was introduced, and now the displaymen stamp the message on a number of the forecast cards which are freely distributed to all points where the navigators congregate or where the marine interests demand these forecasts. This system has been gradually introduced at the stations so that eventually each station will furnish every master in port with a copy of the forecasts and storm warnings. The prime object is to place these forecasts within the reach of all masters on the Lakes so far as it lies within the power of the Chief of Bureau to do so.

Night signals.—At every station where business interests demand it night signals are displayed. Where possible, electric lights have been introduced this season. These are visible at a greater distance than the oil lamps and do not go out during the night as oil lamps do. With high winds the oil lamps knock against the staff and are jarred out, and so it sometimes happens that where we anticipate that our signals are burning and doing good service it is found that they have not been burning for a large portion of the night. In this connection it is proper to bring forward the subject of a permanent staff for the display of signals and the method of fixing the signal lanterns to the staff. An iron or steel tripod 50 feet high with a pole extending 30 feet above the top would make a substantial permanent staff and the lanterns can be fixed to these so as to make a very creditable display, and the signal lights would not be extinguished during high gales, when they are of the most importance.

Our telephone service.—The Bureau maintains two important telephone lines which have paid many times for their installation and maintenance. I refer to the lines between Alpena and Thunder

Bay and Middle Islands. These lines were established at a cost of $20,000, and have been used extensively in saving vessels and property. In one instance the use of these lines was the means of saving a steamer and cargo, the value of which was placed at $750,000, and many other instances could be given of the great value these lines have been to the marine interests of the Great Lakes. Alpena, lying so far in on Thunder Bay, is of very little service to vessels on the fairway of Lake Huron, but these vessels pass one or both of our display stations on Middle Island and Thunder Bay Island on their way up and down the Lake close enough to see the signals. We also maintain telephone service with the Life-Saving stations at Pointe Aux Barques, Lake Huron, and at Big Sable Point, Lake Michigan, signals being displayed at both points, and the telephone lines frequently used for the protection and saving of vessel property. These stations have been of such value to the marine interests that it is proper to state a telephone line between the mainland and South Manitou Island, Lake Michigan, would also be of great service to the Bureau and the mariners.

In concluding this somewhat lengthy paper I desire to call attention to one or two stations where reports would be of great service to the marine interests and enhance the value of the information given out by the Bureau. One is at Mackinaw, where the vessels pass to and fro in the mighty commerce of the lakes; one at Eagle Harbor, on the extreme point of Keweenaw; a third is at Whitefish Point. The first, because all vessels are reported from Mackinaw, and when we had a station there it was used as much by the marine interests as any on the lakes; second, Keweenaw Point juts out into Lake Superior and causes vessels to make a long detour to get around it, and we have no reports from that section of the lake. I am convinced that Marquette does not give the proper record from that portion of the lake. Several very serious disasters have occurred along this peninsula during the past few years. Third, at Whitefish Point vessels lay to in stormy or foggy weather, and being some 60 miles from the Sault as well as at the outlet proper of Lake Superior, the wind and weather conditions are very different from those reported from the Sault. This can be simply illustrated by considering the reports during the past season on Lake Huron from Alpena and Middle Island. At the latter point the wind is always stronger and often varies in direction from that reported at Alpena, some 15 miles away on the bay.

Finally, two important points should ever be kept in view; first, that the storm signal should only be displayed for important storms, advisory messages at other times; second, that an easterly signal should never be displayed during the prevalence of westerly gales, since the systematic methods of distribution of forecasts and storm warnings serve to assure the forecaster that each master has such information in his possession as promptly as possible.

Mr. Mitchell. I would like to ask if Mr. Conger can give us the relative difference between the velocity of winds prevailing; that is, is a 25-mile wind from the east as dangerous as a 30-mile wind from the west.

Mr. Conger. It is not a question of velocity of wind. So far as

velocity is concerned, there is no particular difference whether it is easterly or westerly. There is no particular point as regards the danger from wind velocity; it is simply a question of the location of the cities.

Mr. MITCHELL. I ask the question because there is some similarity between the conditions prevailing on the lakes and those on the south Atlantic coast. A wind velocity of 50 miles an hour from the southwest is not so much to be dreaded as a wind of 25 or 30 miles from the northeast. Of course southwest and west winds are offshore, while the other is from the ocean.

(*b*) *Are the present warnings and displays by flag and lantern the best that can be devised for the Atlantic and Gulf coasts?*

JOHN W. SMITH, Boston, Mass., and ALEX. G. MCADIE, New Orleans, La.

Mr. SMITH. In so far as has been indicated to me by expression from the public and from those especially interested in wind signals the present storm warnings are satisfactory. I am personally acquainted with the officials and numerous members of the Boston Pilot Association and the Marine Department of the Boston Chamber of Commerce, also with many masters, owners, and agents of vessels plying the waters of the Atlantic and Gulf coasts. In discussing the matter of wind signals with them on various occasions I have heard no expression of dissatisfaction with the lanterns and flags as now used. Neither have suggestions been offered for improving the signals. On the other hand, I have often heard the same parties commend the Bureau in the highest possible terms for timely warnings that have proved of the utmost value in saving life and property. While all this is true, and while the present system of wind-signal warnings might continue without complaint, unfavorable comment or adverse criticism, I am strongly of the opinion there is great opportunity for valuable improvement, particularly in the day or flag signals. I have for a long time entertained decided ideas as to how the flag signals might be improved, providing *flags* must be used. Some of these ideas have been expressed to the Chief of Bureau by me in letters and reports. I am of the opinion that the *colors* of the flags used should have no significance or meaning. My reason for this opinion is that the flags are most frequently displayed when the weather conditions are such that it is difficult, if not quite impossible, to discern or distinguish colors at any considerable distance. This statement is based on knowledge obtained from personal observation at various times and places. I think that perhaps this defect in our present system of warnings might be overcome, to a large extent by using flags of various forms, such as square and oblong; also pennants and streamers, and let the warnings be conveyed in this way, rather than through the colors. I believe that the shape of the flags and their positions in the display or hoist could often be distinguished when the colors would not be visible. This system of display would probably be more economical than the present one from the fact that the flags as now used must often be discarded on ac-

count of being discolored, while yet otherwise in good condition.

I am further of the opinion that a more decided improvement could be made by wholly discontinuing the use of flags and following somewhat the Canadian and other services by substituting cones, drums, and cubes. It is well known that flags can not be seen even under favorable weather conditions when flying to or from the observer, or in the line of vision, nor when hanging limp in calm weather. This defect could be overcome by the use of fixed symbols, something after the pattern I have mentioned or proposed, or perhaps by the use of semaphores. I am convinced that some such improvement in the flags or day signals would be a most valuable and highly appreciated addition to the system of storm warnings of the United States Weather Bureau. To discontinue the use of flags would doubtless entail quite an additional expense for signal equipments. This, however, would be in the beginning only, for after once being installed, I am confident the cost of maintenance of the new system would be much less than for flags. I, therefore, suggest and recommend that the matter of the change in the flags or their discontinuance and the adoption of a new system of signals receive careful attention and consideration.

In connection with the display of flags as now used, I favor and recommend a more frequent, in fact a very liberal use of the information signal. This oftimes affords valuable information to the marine interests when it is impracticable to issue a definite warning. In fact, I am almost convinced that at times the information signal is all the warning that is required. In my opinion another weak point in our flag warnings, is that the orders for a change in flags indicating a shift or change in the wind direction are received too late, or after the wind has changed. The original display or hoist of flags should therefore, when possible, be such as to express the direction to which the wind will most likely shift. If this is impracticable, then the orders to change the signals should be issued in due season. I think the opportunity for improvement in this direction is great.

Another matter which I think might be considered is the display of the hurricane signal. I am not favorably disposed toward this as now used. As regards my own station, Boston, it is not popular, and I sometimes think the reputation, or credit, of the Bureau suffers at each display. This was certainly true for the first display of the hurricane signal. Perhaps the public expects too much; anyway, I believe it should be seldom used, and then when the doubt as to full verification is at the minimum. Successful displays are conspicious evidence of the great worth of the Bureau.

As regards the signal lanterns, or night signals, it occurs to me there is little opportunity for improvement, where the standard or large electric lanterns are used. A point to be observed in the use of these lanterns is, to see that they are located far enough apart on the staff or support so that the lights do not blend at the most distant point at which they are likely to be observed or become useful. My lanterns are twelve feet apart. They were originally six, but it was ascertained by test that the distance should be increased to twelve feet. I believe these remarks cover the principal points wherein my knowledge and experience lead me to believe improvements can be made in the flags and lanterns as now used for the Atlantic and Gulf coasts.

Mr. McAdie. Every signal may be considered from at least three different standpoints. First, we have the signal as it is made; second, we have to deal with the transmission of the signal and the various ways in which communication can be maintained; third, we must consider the signal as it reaches the receiving station and the means there at hand to make the signal of real value. To illustrate: A message wigwagged from the shore to a man at sea in a boat without oars and entirely unable to move toward the shore is of doubtful value, unless the means of relief are at hand. Again, a light burning on the shore and obscured by fog is valueless. A signal transmitted by air waves as with sirens may be deflected and rendered misleading.

Under the first heading, that of the signal itself, we must consider legibility and ease of interpretation. Again, signals must be durable, economical, simple. On all these points, I think that the Weather Bureau signals in present use can not be very much improved upon. I do not agree with those who advocate the semaphore, cone, and ball, and other devices.

Under the second heading, "Methods of communication," I hold that the best signal is a telegraphic or telephonic message sent directly to the party most interested. I do not believe that our signals, especially storm signals, as displayed on the roof of some one high building in the heart of a great city are of much value to the community. It has been my experience that whenever such a signal is displayed the public makes reference to the small cards explaining such signals. The mere fact that such a card of explanation is necessary is to my mind proof that the system is too complex. Our hurricane signal is distinctive, so also is the information signal. Our other signals are confusing. The attempt to convey information of wind direction in a signal is not always successful. The value of wind directions varies with localities. What is a dangerous wind in one locality is a desirable wind in another. Moreover, the wind changes direction in some localities very suddenly. With our northers, winds have been known to change in the space of five minutes, and signals have been displayed for southeasterly wind in the face of howling northers. In all such cases the information signal should be displayed and the local office trusted to distribute all other information about the storm.

Finally, far too many signal orders are issued. Advisory messages are far preferable to signal messages unless the disturbance is so marked that the emergency signal is required. The points of improvement in our present methods are fewer signals, many advisory messages, and reliance upon the judgment and skill of the party receiving the signal or message.

Professor Moore. In regard to Mr. Smith's suggestion that we use the information signal frequently, I will say that it occurred to me, when serving on the lakes, that we were using too many—the information signal, the cautionary signal, the storm or storm and hurricane. I think the information signal now is quite well superseded by the frequent information message, a copy of which is, at every port, placed in the hands of the master of every vessel, rendering it somewhat unnecessary to raise the information signal, which simply says that

the observer has information useful to him. We send the message direct to the master and obviate the necessity of putting up too many signals.

Now, as to the change in wind direction, I think both Mr. Conger and Mr. Smith have suggested that the wind direction on the signal display should be changed before the wind shifts. We are assuming, of course, that the official signal went up in advance of the storm, as it does in nearly every case. Now nearly every vessel master knows that if the indication is for a southeast wind, it may veer to the south or southwest, but if the signal is raised for a northeast wind, he is somewhat in doubt, because it may back to the north or northwest. But the point I want to make is that such officials as Mr. Smith and Mr. Conger have authority to change these signals and telegraph their action to Washington. You also have not only discretion but you are encouraged to telegraph the Central Office your opinion on a signal at any time.

Mr. Chaffee. I think the direction signal is very important to the Atlantic coast interests. At Wilmington, when I had charge of that station there, and at the mouth of Cape Fear River, frequently vessels would come out of the river from Wilmington, bound across the ocean; when they left Wilmington, 40 miles up the river, there were probably no signals at all displayed, but during the time it took them to go down the river and pass out, storm signals would be ordered at Wilmington and repeated at the mouth of the river. Now, if that signal indicated an offshore wind, the vessel should keep on, but not having the direction signal they would have to drop anchor, row 8 or 10 miles ashore, get information that the wind was fair, up sails, and get out to sea. The direction signal, I know, in several cases has saved just that delay.

Mr. Sims. I desire to call attention to the fact that it is possible to convey information of extreme importance along the Atlantic coast, and also in the Gulf section, by means of a simple mechanical contrivance that can be placed within a distance of 3 to 5 miles of a settlement, which would give ample warning to the settlers of the section that a tornado was approaching or a wind velocity of from 40 to 60 or 80 miles an hour, or any velocity you deem it important for them to have knowledge of. You simply make a loop in the telegraph line at a point from 5 to 6 miles from the settlement, and upon every pole of the loop place a pointer properly weighted, and also a small board guyed with a wire capable of standing a strain of 40 miles per hour, or more; when the wind attains a velocity of 41 or 42 miles that wire will be broken, the circuit completed, and an alarm sounded in the settlement that will give workers in the field

from five to ten minutes to hie to places of safety. Also, with slight alterations, the contrivance alluded to would serve a good purpose in the vicinity of reservoirs and places where water is stored.

Professor Hazen. We are somewhat at a disadvantage here in that each one is looking at the question from a different standpoint. I have noticed that of those who have spoken one has advocated one thing, and another just the opposite. Now the forecaster at Washington is in a quandary to know how he is to satisfy all interests, and we must be very careful to bear in mind that the larger steamers are not the only vessels we are warning. They, especially sea-going steamers, care very little for signals, but on the lakes we have coal barges which can not stand a wind of perhaps 30 miles without being sunk, and on the sea coast we have vessels which demand the signal larger vessels do not care for. Now, it seems to me that while the message is all right for the larger interests, it does not reach the smaller interests, to which our signal is more important than to the larger vessels.

In regard to the use of the drum and cone, it is a surprising fact that the Belgians and English, and several other nationalities are using, and have been using these signals for twenty years. Now, why do they do it? It seems to me there must be a great deal of merit in that signal. I have thought, when investigation was made some years ago at Washington into these drum and cone signals, that there was too great belief that the flag signal was all right, and not enough thought given to the cone signal. I think possibly we can advance in that direction. I would like to see experimentation continued along this line, to see if the foreigners are right in this matter and we wrong. As to the different shape of the flags, when a flag is tight down to the mast you can tell nothing about the shape. In such cases I think the color very important, and it seems to me that the signals which have been changed from time to time are nevertheless as near the best as can be had, so far as our experiments up to the present time indicate.

Mr. Mitchell. I think there is one point of very material importance in discussing signal displays. I refer, of course, to my own section of the country, Florida. As I said a moment ago, when I approached Mr. Conger on the question, a velocity of 25 miles from the west will not delay a vessel sailing from Jacksonville to sea, because there are no breakers on, and she proceeds without hesitation, while a wind of 25 miles from the northeast or east does affect her proceeding very materially; and I have had masters of vessels come up to the office and ask particularly regarding the expected change of wind, because they desired to avail themselves of it; and

although I had orders to do so, I have felt a delicacy at times, in hoisting a northwest wind signal; that vessel master desired that very wind. Of course it is impossible for the Central Office to appreciate the situation at every station, and in such cases it is the duty of the official in charge to apprise the Central Office of the facts in the case.

Regarding information signals and other signals displayed along the south Atlantic, experience justifies me in finding no fault; we have had no complaint from any source. The people have learned to respect them down that way, and when we hoisted the information signal on the first of October, nearly thirty-six hours in advance of the recent hurricane that passed up the coast, and the hurricane arrived on time, of course it emphasized the fact that we knew what we were talking about, and the people gave us due credit.

Professor Moore. The discussion that has taken place about the direction signal seems to me to raise the point as to whether we should hoist the signal for a wind that is offshore, and therefore not dangerous. I always consider that when we give the direction signal mariners know the velocity we expect to get for that signal, and they may put up sail or get up steam and go out in the face of the signal if it says offshore. It does not necessarily mean danger, the way I interpret it. It means an offshore wind, and if you are going to a distant port and don't want to come back, go ahead; but if you have a small vessel and want to return in a few hours, then don't go. The mariner will make his own interpretation if you give him the facts. By the information message which we have sent so frequently during the past several years we keep vessel masters informed every few hours of the movement of the storm. The storm center has moved so many miles since last report; it is increasing or it is decreasing; the storm is dying and will not come to you; or, it is increasing and will come to you with great fury; or, a storm is coming, don't go out. Such messages keep the mariner fully in touch with the storm's progress, and he is able to make his own deductions. If we give him all the facts we have in our possession, he will make the best use of them and apply them to his own case.

As to the flag signal, that has always been a question. We have not yet been able to find anything better than the flag. Professor Hazen says that as the Belgians have displayed form signals for so many years, it must be evident that they have value. I may say, however, that we have displayed flag signals for twenty-six years, so we may be assured they are fairly successful. In fact, I don't think we have much to learn in meteorology from foreigners. I heard the presiding officer of the geographic section of the British Association for the Advancement of Science, two years ago at Toronto, say that

the meteorological service of the United States Government was the admiration of every Briton and every scientist of the old world.

Professor ABBE. The cone and drum signals have the great advantage that they can be seen from all directions, but they are pretty heavy things to handle and are not raised up very high. Our flags go to the top of very tall masts and can be seen a great way off.

The Convention, at 12 (noon), thereupon adjourned.

OCTOBER 13, 1898: AFTERNOON SESSION.

(c) Possibility of giving warnings of northers, cold waves, and heavy snows to stock-raising interests forty-eight hours in advance.

F. H. BRANDENBURG, Denver, Colo., and E. J. GLASS, Helena, Mont.

Mr. BRANDENBURG. As is well known, cold waves, northers, and heavy snows are especially severe on the Great Plains. In the past few years no severe storms have occurred unannounced, so far as I know, though occasionally the warnings were in point of time too late to reach the interests scattered along the eastern slope of the mountains from the British Northwest Territory to Texas. This arid and semi-arid region being especially adapted to grazing, millions of dollars are to-day invested in cattle and sheep. No interests are more affected by winter storms than those of the live stock. Next to these storms, and not much less serious, are the cold rains and wet snows of spring. Coming as they do at the lambing season, and at the time when stock cattle are poorest in flesh, considerable losses always occur. The cold rains are even worse than snow, for they penetrate to the skin.

A great change in this business has taken place since early in the eighties. In those days large herds were driven from Texas and turned loose on the ranges of Colorado, Wyoming, and Montana during the summer; if gathered at all the following spring these were found by the round-up scattered hundreds of miles to the southward, where they had drifted with the wind. At the present time large open ranges and vast herds are for the most part things of the past, except in Montana. The herds are generally small, and in the hands of ranchmen, and, though obtaining the bulk of their sustenance on the adjacent open range, can be gathered at short notice and cared for during storms. This change in the manner of conducting the business makes it possible for the industry to profit by the storm warnings of the Bureau, especially if it be feasible to make these forty-eight hours in advance.

The difficulties attending the making of predictions so long in advance are considerable, owing to the influence exerted by the Continental Divide and the nearness of the interests to be protected to the locality where these storms originate. As every cold wave that sweeps over the Great Plains is the joint product of a strong anticyclone over the north Pacific or the British Northwest Territory, and of a depression of more or less intensity in the south, 48-hour warnings must in the majority of cases be based not on a high area, but on the position of the low area and the shape or type of the isobars.

In many instances the low area in the south is ill-defined, or that region may be occupied by an area of moderately high pressure. Increased warmth and cloudiness on the eastern Rocky Mountain slope with southerly winds in central Texas often give valuable indications of the formation of a disturbance. Then, again, these signs may be lacking east of the mountains, but a low may apparently occupy Arizona. The latter is often misleading, but when the isobars in the distant south run from east to west, with little curvature, and the arrows at Arizona and southern California stations point southward, it is safe to conclude that within forty-eight hours a low will make its appearance over west Texas or New Mexico. Meanwhile, if a high area is not already present in the northwest one is likely to form; its intensity, however, is difficult to conjecture. If we wait for the high area to develop, its growth and movement are so rapid that scarcely twenty-four hours elapse before the front of the storm is well on its journey southeastward, its progress being facilitated by the down grade.

The region west of the Continental Divide rarely suffers from the cold waves which advance from Montana, but the high pressure areas of the north Pacific, especially when they move well up over the northern plateau before moving southeastward, often cause rapid and marked falls of temperature in that region, even though the high be attended by temperatures above freezing in Washington and Oregon. Often the progress of these cold waves from the north Pacific is so rapid that a 24-hour warning is all that can be given, for the mountains do not impede their progress as they do that of the low areas. These highs bring snow to both slopes, and when the low is in the form of a trough reaching from Arizona to the Great Lakes the fall of snow is heavy and a sharp fall of temperature follows, principally as the result of unobstructed radiation. The movement of the high being southeastward the trough is cut in two, the northern half moves northward and the southern half becomes the principal storm. If, in winter, predictions of a cold wave, or if, in the fall or spring, predictions of a heavy snow, be delayed until the high forms, then a long notice can not be given to the ranchers. But if the forecast is based on the trough, which first appears as a low over Oregon, the next day as a trough over the Plateau region, the northern end of which usually moves the faster, then it can be made with great accuracy on the first appearance of rising pressure over California or to the northward. Forecasts of severe storms, with the above distribution of pressure, can be made with greater accuracy than when the high is north of Montana.

Existing instructions require that certain changes in the barometer during the two hours preceding the observation be telegraphed by a special cipher word from selected stations. As the stations in the west, as a rule are far apart, and moreover as so large a per cent of the storms cross or originate in the Rocky Mountain region, it is thought that good will result if all the stations west of the ninety-fifth or one-hundredth meridian be required to add the word representing the change. By means of the additional stations that are to be established west of the Continental Divide it may not be so hard in the future to determine where a given low will cross the main range, whether in Montana or Wyoming, or through the Royal Gorge of the Arkansas, or the low mountains of New Mexico.

It may not be out of place to refer to what, to me, seems to be the principal cause of such failures as occur in connection with forecasts of cold waves for the middle eastern slope, based on high areas over Alberta. These failures occur principally when a low overlies the northern Plateau and British Columbia, for then the latter may be expected to exert the controlling influence on the weather of the middle Rocky Mountain region, and we have the anomaly of winds blowing against steep gradients. When, however, a high occupies the upper part of the northern Plateau precipitation and cold overspread the entire State.

In view of the value of barometric readings from British Columbia, it is to be regretted that the reports from Kamloops are so uncertain both as to their receipt and accuracy. Turning now to the south I venture to express the belief that reports from Chihuahua, Mexico, would be of great value in connection with 48-hour predictions of cold waves in the United States along the eastern slope of the mountains, in connection with northers in Texas as well as with the heavy precipitation of the central valley.

Professor Moore. I am sorry we can not give more time to the discussion that might be engendered by Mr. Brandenburg's paper. He is one of several forecast officials that were recently commended as a result of the verification of the work of the local officials in comparison with the state officials. His differing forecasts showed a very high percentage; showed that he had differed with such judgment as to have improved the forecasts. I commend the study of his paper to every local forecaster in the Rocky Mountain region. All these papers will be issued in a pamphlet soon after this Convention adjourns, and to the forecasters of the Plateau region I especially commend the study of Mr. Brandenburg's paper; he can be considered an expert in forecasting in the Rocky Mountain region.

Mr. Glass. In writing on this subject we have first to become acquainted with the three principal points on the subject, namely, cold waves, northers, and heavy snowstorms. A cold wave is a fall in temperature of 20° or more to a minimum of 32° or less in any twenty-four hours, without regard to the wind velocity or direction, while a norther is a fall in temperature to below freezing point with the wind 25 miles an hour or more from a northerly direction, accompanied by heavy snow.

Meteorology is an inductive science. It is a science in which we gather the facts by observation and arrive at the laws of the weather by induction therefrom. We are peculiarly situated for gathering these facts; we are located at the bottom of an ocean of air, composed of invisible gases, which on pressure becomes warmer or upon being rarified become colder. This wonderful mixture of gases, although very light and invisible, is weighed by the barometer, its movement is indicated by the anemoscope, and its velocity is measured by the anemometer. The thermometer also fills a most important part in our work of gathering facts relating to the air. One essential property of the air is its power of holding vapor of water; another is its ability

to expand when heated; another is the increased capacity of heated air for carrying aqueous vapor; finally its property of cooling by expansion, thereby causing condensation of vapor and precipitation of moisture in the form of rain or snow.

The sun's heat is the prime power that underlies our entire meteorological science. By the sun's heat the air in a certain locality becomes heated, expands, and rises, while the surrounding surface air moves to replace it. All bodies moving on the earth in any direction in the Northern Hemisphere are swerved to the right by the earth's rotation. The movement of the air in the above case conforms with the law just cited, and a gyratory motion is commenced; the nucleus of a storm is formed and it starts on its eastward journey. These areas of low pressure are followed by high pressure areas, the average rate of travel being about 37 miles per hour during January and February, but gradually decreasing until July, when an average of 22 miles an hour is recorded.

It is generally understood that nearly all cold waves originate to the north of the United States and travel in a southerly or easterly direction, and pass along the east side of the Rocky Mountains accompanying areas of high and low barometer. These are the barometric waves that we must consider in the discussion of our subject. When the center of a storm has passed a given place, the winds veer suddenly to the west or northwest. When the cold air that rushes in causes the temperature to drop 20° or more it is called a cold wave. It is commonly said in the description of these storms that the cold winds come from the north where the storm originated, but on the contrary, by the action of the high and low areas, the cold may be generated and brought down from above in the near vicinity of the storm itself.

The conditions most favorable for cold waves in Montana are the presence of an area of low barometer in southern Idaho or Utah, and another low area coming down from the northwest followed by a high, entering Montana near Havre. This barometric depression is accompanied by southerly winds, and by abnormal warming up of the atmosphere in its southeast quadrant. When the center of the storm is past, the winds veer to the west with increasing velocity, and the temperature falls 25° to 40° in a very few minutes. This class of cold waves is always accompanied by heavy snows and high winds, thus combining in one storm the three principal points in our subject. This is the kind that is most dangerous to the cattle and sheep interests, because the warm weather preceding the storm induces the herder to drive his flocks away from the place of shelter only to be caught by the cold waves and northers. This class of cold waves travels much faster than those accompanying the high areas, and many incredible stories could be told in the history of Montana cattle and sheep industries of the destruction by these storms or the narrow escapes therefrom.

The large cattle companies of the State can not use forecasts to advantage, as it is impossible to keep any knowledge of the number or condition of the stock on their extensive ranges, except at the spring and autumn round up. The spring round up is for the purpose of branding the increase, and the fall gathering is for shipping purposes. We have interviewed many of the large owners of cattle who reside at Helena, and while they are much interested in the work

of the Weather Bureau they regret to acknowledge that they can not receive the benefits of the warnings. The larger owners of cattle generally have summer and winter ranges for their stock, and at the round up the cattle are changed from one to the other according to the season. The winter range is located, where the most shelter can be had for their stock during the prevalence of the cold waves. Accurate long-range forecasting by seasons would greatly benefit the cattle industry. But while the large owners can not utilize the warning, there are many farmers and ranchmen who possess small herds of cattle that aggregate thousands in all, who reap the benefits of the forecasts, and to whom a warning of twelve to twenty-four hours in advance is very beneficial.

The sheep industry of Montana is quite large and is greatly benefited by warnings. The facilities for distributing cold wave forecasts to the sheep men are very good, and they can be protected by these warnings. Sheep are always accompanied by a herder, and in case of a warning he will either house his herd or drive them northwest of their shelter so that when the storm arrives the herd will drift home with the storm.

The cold wave that comes with a high barometer without wind is not so disastrous to stock. The cold air settles and stratifies along the ground, there being no clouds, the greater portion of the cold is derived from radiation. This class of cold waves, as a general rule, does not worry the stockmen very much, if the ranges are free from snow. These travel very slowly and cause a long protracted cold period. On several occasions, while the thermometer registered —25° to —30° at Helena, whose elevation is 4,108 feet, the temperature of a place less than 8 miles away, at an elevation of 7,000 feet, was being registered as above the freezing point, and snow was rapidly thawing, thus showing a thin stratum of cold air at Helena.

The possibility of making warnings forty-eight hours in advance of cold waves, northers, and heavy snows is not very encouraging for localities so far north as Montana. Our knowledge is so limited as to the probable direction and motion, and their rate of travel is so rapid that it is very difficult to determine whether their course will be east over Manitoba, or southerly through Montana, the Dakotas, and the upper Mississippi Valley.

It is thought that the important facts to be gathered from aerial observations obtained by kite flying will reveal new laws as to the currents of air in the upper atmosphere, and will enable the forecaster to be warned in advance of the approaching surface conditions, thus enabling him to predict, with certainty, forty-eight hours in advance. But with our present limited knowledge it is believed to be impracticable to make 48-hour forecasts west of the Mississippi River, unless stations be established over the Northwest Territory and Alaska.

(*d*) *Warnings of washouts, floods, cold waves, and heavy snowfalls for the benefit of transportation companies.*

J. Warren Smith, Columbus, Ohio, and T. S. Outram, Minneapolis, Minn.

Mr. J. Warren Smith. I have just one word to say to forecast officials relative to flood warnings, namely, that they take into account not only the depth of snow over the drainage area but whether that

snow is in stable or unstable equilibrium; whether it is full of water, so that a small rain will cause a flood, or whether it is mostly in the form of ice. I think in addition to reporting the depth of snow reporters should give the water equivalent of the snow and whether the ground is frozen or not. I believe that it is important that transportation companies, especially during the spring season, should be informed in advance of the condition of the snow, of the condition of the soil, whether it is full of water or whether it is full of frost, whether the roads are liable to be washed out easily, and that we should supplement our flood warnings by keeping transportation companies informed in advance of these conditions. In arranging for these flood warnings for transportation companies, I also believe that we are not particular enough to see that the right man gets them. We should make a personal visit to the roadmaster or chief official of each electric or steam railroad, and be sure the warning reaches not merely some official but the right man at the right season.

Mr. Outram. In the discussion of the subject, "Warnings of washouts, floods, cold waves, and heavy snowfalls for the benefit of transportation companies," which has been introduced by the previous speaker, the interest naturally attaches to the following features, namely, the present value of these warnings to this large class of our industrial interests, their dissemination, and the possibility of improving both the forecasts or warnings, and the manner of placing them where they are needed.

Floods.—In its flood service our Bureau has been remarkably successful, in fact its system of flood warnings becomes its most valuable feature during those seasons when great floods create such enormous loss of life and injury to property of all kinds exposed to their fury. Transportation companies, on both land and water, value these warnings most highly, since they are so timely that by them they are enabled to remove valuable freight to places where the rising waters can not cause injury. The masters of vessels have time to place their craft in advantageous positions, where the violence of the flood is less, or where the ice, which so often accompanies the flood, can not wreck them. The railroad companies along those parts of their lines subject to high water in flood years have opportunity to strengthen weak places in the road bed, to see as far as possible that there is a free discharge of water through bridges, culverts, etc., and so to arrange their forces of workmen that they may be ready at every point to act when the danger arrives.

Washouts.—I consider washouts as incidental to floods, for where there is not an excess of water from some source there can not be washouts, and warnings of floods certainly convey to railroad men at least the possibility of washouts. Our most sanguine forecasters can hardly hope, at present, to be able to issue warnings of those small and local but sometimes disastrous floods and their attendant washouts, resulting from the so-called cloud-bursts. To do this would require a skill in forecasting that as yet we can scarcely hope for.

Distribution.—The subject of the distribution of flood warnings to boatmen and others who are not in frequent communication with our stations, or substations, and the improvement of the flood service by increasing the number of precipitation stations and river gauges, or

in any other way, I must leave to those whose work in this part of the service has made them more competent to discuss the subject than I am. The special difficulty in conveying information to railroad officials at such times is a break in the telegraph wires, but the characteristic energy of the railroad man will overcome many difficulties when he needs to obtain something which he prizes as highly as he does these warnings.

Cold waves.—Cold waves are of frequent occurrence in our northern part of the country, and they are not infrequent in other parts. They are such unwelcome visitors to our railroad interests, that when the subject of Weather Bureau is mentioned to him, the railroad official's first thought seems to be of a cold wave. During the past four years or more a law firm in Minneapolis has been especially looking up the cases of damage by cold to fruit shipments while in the care of the railroads, and has collected large sums of money from the companies so frequently, that the fear of losing perishable freight by exposure to cold seems to be instilled into every employee's mind so deeply that cold-wave warnings must be his hourly dread during their whole season. No one can compute the enormous value of the shipments during the cold-wave season of such perishable freight as tropical fruits, apples, potatoes, eggs, groceries, drugs, and many other commodities, seeking a market in all directions over the immense territory that is liable to injurious temperatures. As the railroad companies are responsible for the good condition of all freight delivered, it is easy to understand the benefit of a system which warns them of that which causes their heaviest losses, and it is no exaggeration to say that the pecuniary advantage of the cold-wave warnings to these transportation companies is beyond the possibility of estimate.

To enumerate instances when, on receipt of cold-wave warnings, whole trains of fruit have been run into roundhouses for shelter, when shipments have been held back or their character changed, when apples or potatoes have been hurried east, and held back from the west, or when the freight cars have been warmed by lamps or stoves placed within them for protection against cold, would only take up time and add nothing but detail. The cold-wave warnings, together with the regular weather forecasts, are used by many train dispatchers in deciding whether their trains shall be lightly or heavily loaded, and whether they shall make long or short runs between switching places. It is a daily occurrence during winter for freight agents to ask me by telephone for the probable night temperature, and the information is used in deciding as to the disposition of freight in their care over night. It must not be gathered from the preceding that the railroad officials think the Bureau has attained absolute certainty in predicting injurious temperatures; they regard them only as warnings and as reminders that their freight may be injured if taken too far from shelter. They know that it would not be profitable for them to be too cautious and run no chances at all of injury by cold, as they would then have large damages to pay on account of delay.

Blizzard and snow.—Warnings of heavy snows, or blizzards, as they are commonly called, hold an important place in the beneficial work of the Bureau, but as the warnings are comparatively infrequent they do not attract so much attention as the more frequent cold-wave warnings. A real blizzard is much more severe on trans-

portation than a cold wav , and consequently it is far more dreaded, for it blocks the roads c ompletely and prevents all escape from the cold, which generally accompanies or immediately follows the heavy snow. It is during these blizzards that we hear of the intense suffering experienced by train crews and live stock on the stock trains, and sometimes of the loss of many carloads of valuable freight by freezing. Unfortunately, the snow warnings are not always early enough. When there is a severe blizzard, ample warning and the best preparation that can be invented by man could not keep the tracks open and prevent loss, but timely warnings are useful, as showing the need of precautions for getting perishable freight into safe places, and leaving the tracks open for only those trains best equipped with appliances for fighting the snowdrift.

When the sky over the whole country is beautifully clear, and a high pressure area overlies the whole Northwest, it seems impossible to bring oneself to believe that a heavy snowstorm is impending, and it may be due to this feeling that many snow predictions come too late. Heavy snows seem to snuggle, if I may use the expression, right up under the rear edge of the most pronounced highs, and they move eastward with great rapidity. The distribution of warnings of all kinds to railroad officials is very easy, and I do not see that it can be improved. The information is so valuable to them that they immediately distribute it themselves to all points on their lines where it will be of use. Our Minneapolis officials sometimes get warnings from their Chicago offices before the information can be telephoned to them from my office.

Forecasts.—The remaining point is by far the most important, and that is the improvement of the forecasts themselves. A few years ago the proficiency we have now attained was not dreamed of. A few years hence the advance we have made may be laughed at. Our mistakes are simply the necessary result of our yet imperfect knowledge. Nevertheless continued progress is evident, and with constant application, and the thorough investigation of new fields in the physics of the atmosphere, it must eventually come about that some laws will be discovered by which we can predict the degree of cold in a cold wave with considerable accuracy, and foretell the region affected by it, and also predict the intensity and location of snowstorms. If the imperfect warnings now issued are valuable beyond computation, who dare say as to the value of the warnings of future years, when it is reasonably certain that they will be verified almost to the very letter?

(*e*) *What classes are most benefited by the forecasts? Are they just what are needed? Are they properly disseminated and utilized?*

J. R. Sage, Des Moines, Iowa, and H. C. Bate, Nashville, Tenn.

Mr. Sage. What classes are most benefited by the forecasts? This question has been asked me repeatedly, and I should say that all civilized mankind within the realm affected by the Weather Bureau is about equally benefited. I have had to meet that question at farmers' institutes. "What benefit is it to the farmers?" they ask. Is it not largely for the benefit of commerce? Yes, directly. It is, you might say, almost two-thirds or three-fourths for the benefit of commercial interests directly—transportation lines and the commerce of

the ocean, the lakes, the rivers, and transportation overland. The saving of wheat and other grain on the Great Lakes, the saving of perishable products in transit overland on the railroads—all this directly affects the commercial interests. "Where does that benefit the farmer?" the farmer asks. Would we not be benefited by having five or ten millions of bushels of wheat sunk up in Lake Superior, or elsewhere, and thus lessen the overproduction? But the farmer would not be benefited; he would be damaged. Every hazard there is on the line of transportation between the producer and the consumer is at the cost, largely, of the producer. Every element of hazard in transit of the products of the farm is at the cost of the producer; ultimately the producer and the consumer pay it.

So you can see at a glance what classes are benefited by the forecasts. If you are talking to a farmer, talk directly of his interests, and the wideawake farmer will appreciate the point you make. I could bring you a number of illustrations to sustain my proposition, but I leave you to work out the details along that line. You will find it an interesting study and a profitable thing for the Bureau and the farmer as well.

Mr. Bate. I consider myself fortunate and happy in having to follow my honorable colleague on this question, because he has outlined in such beautiful and eloquent language the facts and propositions set forth in the topic. In hearing these interesting discussions and in looking over the varied interests involved, I am reminded very much of a conversation I once heard of between a very large, muscular man, who went into the subject with a kind of sledge-hammer blow and got there in a few words, and a little, fidgety, nervous man who beat around and finally arrived at the same conclusion by a road ten times as long. The big man said "Do you know, Mr. Dawkins, I think that what is one man's food is another man's poison?" The other said: "Well, I won't go so far as to say that, but I do think I can safely say I am of the opinion that what would be beneficial to one man and pleasant to him, would be unpleasant, and I might say deleterious, or I might go so far as to say absolutely fatal to another."

Now, for example, in the great raisin districts of the San Joaquin Valley of California, a warning of rain carries with it the fear of loss of many thousands of dollars, and to protect the fruit exposed in the vineyards during the process of drying by sheltering it entails a great expense, even if the warning is not verified, while in some sections, either contiguous, or at least not very remote, the verification of such a forecast results in untold benefits; in short, some pray for dry weather, others for rain.

There is scarcely a community in this vast domain of ours that is not directly or indirectly benefited by the daily forecasts or special warnings. In the early summer when the fields show the ripening grain and hay, when to reap or mow becomes a vital question; in the early fall, when the season for frost approaches, forecasts and warnings are noted eagerly by the growers of cotton, tobacco, and other products liable to injury and shortage. In the latter periods, when the time for the seeding of winter grains is at hand, the forecasts of timely showers are hailed with joy; and in the winter, when perishable products are to be interchanged from north to south, and *vice versa*, shippers consult closely the forecasts from the Bureau that

give them time to protect their produce; breeders of fine stock take advantage of the warnings to shelter their valuable droves, herds, and flocks from the effects of severe cold waves; florists and market gardeners prepare for the coming changes; river men watch with interest the forecasts of the rise and fall of the rivers and the warnings of floods, and those who "go down to the sea in ships" are guided in their movements by the signals which give warning of the approach of dangerous winds. I might continue the list, *ad infinitum*, to illustrate how thoroughly the information permeates and affects all classes and conditions of our citizens and their varied industries, but this would far transcend the limits of my allotted space.

As to the second proposition; human wisdom has not yet reached the plane of perfection, therefore the methods of the Weather Bureau are not infallible. It is said, and truthfully, that the science of meteorology is yet in its infancy. As long as we must explore only the bottom of our great atmospheric ocean, and until we can penetrate beyond this lower stratum, we must act according to the lights before us, and give to the people the benefit of present attainments in the deductions from atmospheric conditions as they appear from day to day; as it is, I think the excellence of the information, as is now presented, that is, the rate of verification, can not fail to satisfy a very large percentage of those who would profit by the forecasts, indeed, with existing defects they have become virtually a necessity, and as the public becomes more and more educated to the importance of the Bureau as the protective factor in the economy of our Government, the realization of its excellence, even in its present embryonic state, becomes more and more patent.

Until the systems of signals and other means of reaching the great mass of our people, the agricultural classes, have reached a higher plane toward perfection, we must content ourselves with these methods. Where our railway schedules and daily cross-country mails render it possible to place the daily map or the postal card forecast within the reach of a community it is done through the cooperation of public spirited men, who generously give a portion of their time each day, in supplementing the work of the forecast centers by scattering broadcast from their respective display centers the information emanating from the Central Office, and it is gratifying to know that the efforts made in this direction, and the constantly increasing dissemination of the forecasts, are being more and more perfected and appreciated. As the demands increase I have no doubt that the wisdom of our National legislators will prepare for even a more thorough dissemination of the information than our present limited resources will permit. As it is we all must feel a pride in the successful efforts of our honored Secretary of Agriculture, seconded by our worthy and progressive Chief, in advancing into our newly-acquired territory, and that of our friendly neighbors in the Tropics, and almost simultaneously with the flinging to the breeze of "Old Glory," hoisting the storm signal for the benefit and protection of the commerce of the nations.

(f) Long-range forecasts: Can they be made with sufficient precision to be of general utility?

Prof. H. A. Hazen, Washington, D. C., Patrick Connor, Kansas City, Mo., and B. S. Pague, Portland, Oreg.

Professor Hazen. I will leave the serious side of this question to those who are to follow me, and will proceed in a lighter vein. Our newspapers are very ready to publish so-called forecasts of the weather a month or even a year in advance, and it is remarkable how much confidence is placed in such pure guesses by respectable people. The explanation, in part, at least, lies in P. T. Barnum's *bon mot* "the American people love to be humbugged." It is a well-known fact that we are very prone to remember coincidences in such cases, but very likely to forget failures. It will be of interest to inquire as to the principles on which such guesses are prepared, for, strange as it may seem, all these men have a supposed cause for all the effects they describe as about to occur in a month, year, or one hundred years just as well. All these men adopt cosmical or extraterrestrial forces as acting upon our weather. It is impossible to see how such cosmic force can act to produce a storm unless it act uniformly over a whole hemisphere. To say that a storm will occur on any day and then claim a verification because a storm occurred at one point is of no account really, for two or three storms are active somewhere in the Northern Hemisphere every day.

The moon has been the commonest of all extraterrestrial forces to which weather changes have been ascribed. If the moon can raise a tide of 60 feet in the Bay of Fundy it must produce tremendous tides in the air, and why should not these, in turn, give us our weather changes. The fact that this enormous tide is due to the configuration of the coast, and that the greatest tide in mid-ocean is less than a foot, is lost sight of. One theory asserts that the moon draws the air into a lenticular form, and this air lens concentrates the sun's heat so as to give us severe storms. The moon is known to be inert and dead. Its surface exposed to the sun may have a temperature of boiling water, while at new moon the dark face may have a temperature of 200° below zero, but neither of these conditions affects our atmosphere, and in fact, the most refined methods of observation have shown scarcely the difference of $\frac{1}{1000}$ of a degree as the range of influence from the bright and dark moon.

The planets, however, have yielded the most powerful of all theories for weather changes. It seems most extraordinary that any person, after considering the immensity and power of the sun, could for a moment think that one of his tiny attendants, itself entirely dependant upon the sun for its light and heat, can overpower the effect of the sun, and produce storms of its own in localities. Here is one of these theories:

> The planets, comets, etc., go through a reversed change of motion, volume, distance, and density at perihelion and aphelion each orbital revolution, which are effected through reciprocating electric currents or lines that exist and undulate between the planetary bodies. These changes are the cause of our most violent storms and earth disturbances. The perihelion and aphelion passages of the planets, the oppositions and opposite positions of the superior planets, the inferior and superior conjunctions of the inferior planets, and the eclipses of the sun and moon constitute the first grade of meteoric disturbances.

Others claim that the planet has its greatest effect when it is

farthest from the line between earth and sun, or at quadrature instead of in conjunction. These opposite theories produce the novel result that the fair days of one are exactly the storm days of the other and *vice versa*. Notwithstanding this plain contradiction, however, each one claims a perfect verification for his own guess.

Of course any rigid system of forecasting for a well-defined locality and a verification by a strictly impartial rule would settle the question of the value of these guesses at once, and it would seem as though these planetarians would eagerly accept such methods. On the contrary they absolutely refuse to allow any one to verify a forecast. In one instance one of these men submitted a forecast for each day of a whole month, and also a curve showing the resulting temperature, which he claimed gave a complete verification. After a while the same forecasts were sent back to him and with his curve exactly reversed; that is, the cold points in the first curve were sent back as the warm points in the second and *vice versa*. Notwithstanding this exact reversal in the result, he claimed a perfect verification of the guess.

A thorough acquaintance with the methods of these planetarians will convince any one of the uselessness of such guesses. We must look to the sun alone for all our weather changes. It is very certain that, with a very few exceptions, no definite forecasts can be made for a period greater than forty-eight or, at the most, seventy-two hours; also, that none of our weather changes are due to lunar or planetary influence. Whether we may ever be able to make a forecast three months or even a month in advance is an interesting question. If the state of the ice in northern latitudes affects our weather, then by obtaining information from these far-north points we may hope to give a general idea of the coming season, but even then it will plainly be impossible to make a definite forecast for an individual day.

Mr. Connor. I presume that since the fulfillment of the long-range forecast of heavy rain which floated Noah's ark, and perhaps a thousand years before, there have been a few people, at least, who have considered it within the bounds of knowledge or so-called science to make useful long-range forecasts of the weather, but unfortunately the success and skill of those wise wits of weather, those soothsayers of simoons, those human horoscopes of heaven can be measured only by the diversity of human eccentricity, superstition, and public credulity. There are those to-day who think that the laws governing long-range weather forecasting are hidden in impenetrable gloom, while there are others to whom they are as an open book.

I understand there are a few in our own country who, by some special endowment not known to the writer, can harness their chariots to lines of magnetic force and ride on ether vibrations to the most distant planet, whose sensitive souls are so delicately attuned to the symphony of the spheres that they can ascertain with minutest detail the throbbings and pulsations that will take place in the family of worlds for a year or two to come, and can tell what the effect will be on the varied interests of mankind for the same period, while there are others in the same line of research weighted down by ponderous calculations and stern realities, who, living at the bottom of the aerial ocean, think they are doing well if they can tell their neigh-

bors when to carry an umbrella or when it may be safe to ship a carload of fruit.

I have been so situated for some years past that I could not help but feel interested in this intensely interesting subject, for I am bounded on the north by a long-range weather forecaster, Foster, of St. Joseph, Mo., and on the east by another, Hicks, of St. Louis, Mo. What surprises me more than anything else is that, situated as I am, I have not been influenced so far as I know by thought transference or the psychological communications which are supposed to pass between kindred spirits. But to come to the point: Can long-range weather forecasts be made with sufficient precision to be of particular benefit to the public? I have to answer yes and no; at times, yes; at other times, no. I have tried it and met with success; again I have tried it and met with total failure.

I do not think that it lies within the bounds of human knowledge to make definite long-range forecasts under all conditions, but I do think it possible, *at times*, to make a very good general forecast for a week or two with reasonable precision for certain localities. Some sections of the country present less difficulty than others, notably those having well-marked seasons and uniformity of conditions during long periods, such as obtain on the Pacific slope. I have tried to find cycles when weather conditions repeat themselves, but without success for the section of country in which I happen to be located. I have found but little consolation in the sun spot theory, as the years of supposed maximum or minimum frequency afford no index as to what month may be wet or dry, cold or warm. There may possibly be some reason, unknown to me, for the assignment of numerous and destructive tornadoes and electrical storms to the great solar energy assumed to be developed at the time of maximum sun-spot frequency, but it will not hold very well with regard to precipitation. We are now almost at a time of minimum solar energy as measured by sun-spot periods, and yet my section of the country has received from 9 to 12 inches of rain in excess of normal. Some of the farmers in eastern Kansas and northwest Missouri had to plant corn three or four times this year on account of washouts.

Struggling to find something else that might be of aid, I entertained myself for a time with thoughts on lunar influence, only to find that I could not swear by the inconstant moon. I found that the weather was just as liable to be one kind as another during any of the moon's phases or perturbations.

The next line in which I directed some attention was Professor Bigelow's solar magnetic theory of weather changes, and I will say candidly that I got more satisfaction than disappointment out of it. I have made several very accurate forecasts based entirely upon my humble interpretation of his suggestions, which I can not possibly attribute to chance, and I have made others which, on account, I suppose, of the inverse conditions which the professor mentions in his writings, were conspicuous failures.

The last long-range forecast I made was for carnival week at Kansas City, from October 3 to 8. About September 28 I gave out, with slight reservation, that we would be within storm influences which would give threatening weather and some rains from Friday, September 30, to perhaps Monday evening, October 3, when they should pass off. Tuesday, Wednesday, and Thursday, should be fair, followed by

a change suggesting rain on Friday. In addition I stated that the week would likely be very much cooler than the two preceding, and that people coming to town should bring their wraps and overcoats. It affords me pleasure to state that all this was verified almost to the letter. But that offers no guarantee that the next forecast will be fulfilled. When I consider the solar schemes as a basis for forecasting, I am confronted by the fact that unchanging atmospheric conditions frequently occur over widespread areas during the whole time necessary for a complete solar rotation, and during which every variation shown in the average magnetic curve must have occurred, so that it seems as if great irregularities ought to have figured in the average daily solar impress, or else there must be very unequal distribution of earth currents to be acted upon by the solar forces. Coming nearer home, I will now refer to certain atmospheric conditions, doubtless well known to all of you, which appear at times and which make possible long-range forecasts with reasonable hope of verification. The area of abnormally high pressure which settles over the central Plateau region in the winter season, exerts a modifying influence on the temperature of the Western States. Its permanence covers at least one week, and usually two weeks, and frequently more. From the first phase of permanency it is safe to predict that no very cold weather may be expected for a week or ten days, south of Nebraska and Iowa. This condition prevailed during the greater portion of last winter and, as a result, no very cold weather was experienced. On our neighboring lakes ice did not reach 8 inches in thickness. Again, during the summer months the great south Atlantic high which extends over the southeast portions of the country, enables a forecaster to predict with reasonable safety an absence of rain in the West for nearly a week.

The passage of a series of lows, far to the north, in summer, presages several days in advance dry weather for the West. The series may be anticipated by the very weak high which follows the first low, leaving practically a low belt along the British line to the north Pacific, while pressure above normal obtains over the southern portions of the country. Then again, circular "lows," the center of which do not dip south of the northern tier of States, although rather formidable, usually produce hot and windy weather in the West and Southwest, but no rain. These furnish the greater number of stereotyped conditions when it may be reasonably safe to make long-range forecasts from the maps, and are, perhaps, the most reliable grounds upon which to base them. Regarding the seasons, so far as I know, it is impossible to anticipate their characteristics as to weather details. Should one season show a great excess or deficiency of any element, it would be reasonable to expect reversed conditions the following season, but for definite forecasting it counts for little, and the man who relies very much on it may soon have a "yellow" reputation to carry around with him. Long-range forecasting, except on rare occasions, is full of surprises. I would like to grasp the hand of the one who can do it successfully. I think that, some day, within the lives of present aspiring observers great skill will be acquired in this work, but only when we have fathomed the methods of the great universe builder.

Mr. Pague. On September 30 I received information from the Chief

of the Weather Bureau that one of the Convention subjects assigned me was, "Can long-range forecasts be made with sufficient precision to be of general utility?"

This I construe to be applicable to me in my work in the north Pacific forecast division of the Weather Bureau, and I answer, yes, without a question or a doubt. I answer yes, for the reason that for the past two years I have been making, by authority, long-range forecasts, and they have been of practical utility and value to the farmers, fruit growers, river men, and vessel men. I know they are of utility and value because I have been told so by many interested people. These long-range forecasts cover periods of from three to seven days, depending upon the season of the year and the clearness or decisiveness of the conditions. Long-range forecasts can be made for a period greater than seven days, possibly for a whole season or half a year, when the chain of stations is extended from British Columbia and the Canadian Provinces northward to Alaska and to the Aleutian Islands on the west. The forecast for a period of ten days or more can then be made with at least as much accuracy as they are now made for thirty to forty-eight hours; and these forecasts can be made not only for the north Pacific division, but for the whole Pacific slope and for the greater portion of the northern half of the country east of the Rocky Mountains. These are statements that I know will be doubted and adversely criticised, but the proof of their accuracy is easily shown.

Not many years ago few storms were given credit for having originated or having been first observed on the north Pacific coast, then moving eastward, losing energy and almost identity in their course across the Rocky Mountains, and regaining energy and perfect identity as they approached the moister air of the Great Lakes. Within the last five years I have been informed by a professor of the Weather Bureau at Washington City that, unless the perfect cyclonic movement of the storm area be distinct and well defined, the storms could not be traced with unfailing accuracy across the Rocky Mountains. To prove the storm area, cyclonic winds must be shown at every station. This is an absurd statement, especially so when local winds, due to the topographical features of the country, constantly prevail, no matter what the barometric depression may be. For example, the winds at Idaho Falls almost invariably blow from a low to a high, and the passage of a storm area across the Rocky Mountains, due to such local winds, was doubted because the cyclonic movement was not distinct or well defined.

A successful forecaster must understand the geographic as well as the meteorologic conditions of his division, and it has been my pleasure to note the following characteristics in the movements of the areas of high and low pressure. As the heat of summer passes away, the areas of low pressure move southward from Alaska to about the forty-eighth degree north latitude, on which parallel they pass eastward, almost losing identity when they cross the Rocky Mountains; but when once as far as the Dakotas they regain energy and move onward. They continue in their comparatively low latitude until the increasing heat of the next summer forces them northward. These are two distinct and well-defined movements of low pressure. The highs, also, have two well-defined movements. The permanent home of the highs is off the southwestern California coast several thousand miles, and the

center moves north in summer and south in winter. The movement is shown on hydrographic charts and in all standard works on meteorology. The summer high moves northeastward along the coast line to about the fiftieth parallel, thence eastward. In winter the high moves northward to about the fortieth parallel, thence eastward, and forms, or helps to form, the permanent high in the plateau region of southern Idaho and adjacent regions, and this is found there during almost the entire winter season. The other movement is the high from the north, appearing first in Alberta, thence moving southeastward to the Great Lakes, frequently giving cold waves to the country east of the Rocky Mountains. These movements of high and low areas are well defined, and when once the subject is followed closely and the causes clearly defined then will forecasts for longer periods be more accurate and of more value. There is a reason for the movements of the lows and highs, and this reason is the stumbling-block to success in solving the problem. The movements are clear, and the reason for the movements may also be clear when discovered. It is the knowledge of these movements that enables me to make the long-range forecast. The lows never appear off the Washington coast during the summer season, nor do the highs appear over the Plateau region in the same season. The movements are regular; hence the success in the present long-range forecasts. The change from the dry to the wet season and from the wet to the dry have been announced by me for the past five years and not one error has yet been made. This success is the reason why I say so emphatically that long-range forecasts are possible and that they can be made of utility and of value.

(*g*) *Forecast distribution: Should the wording of the forecasts be confined to the vocabulary of the present logotype outfit? Is it advisable to extend the vocabulary of the logotype outfit?*

F. P. Chaffee, Montgomery, Ala., and G. M. Chappel, Des Moines, Iowa.

Mr. Chaffee. Next to the accuracy of the various forecasts and warnings, the most important subject in connection with the work of the Bureau is that of forecast distribution, so that the valuable information, collected and collated at a great cost, may be quickly disseminated among the people. By the public spirited cooperation of the distributing displaymen, the logotype system has been the means of placing our daily forecasts in nearly every post office of any importance, and in time to be of direct benefit to the various interests of the different sections. The logotype system of distribution has certainly been the best means of familiarizing the people with our work and showing them what we are doing for them. In my opinion the daily forecasts should be made to conform to the logotype vocabulary, so that the distributing agents may not be troubled with interpreting the forecasts, the public interests endangered, and the reputation of the Bureau jeopardized by incorrect interpretation of the official forecasts.

The present logotype vocabulary is ample to cover any forecast or warning, and its extension is not deemed advisable, as the outfit is now so complete and thorough that any addition to it will make it unwieldy and troublesome. The greatest difficulty experienced in

the logotype distribution is in stamping the cards plainly and uniformly. The present logotype holder and inking pad might be improved on by devising a self-inking spring logotype holder with the bed of the holder channeled to receive the logotypes and hold them securely while the stamping machine is being operated. Such machines, it is thought, could be made so cheaply as to justify the Bureau in supplying them to such displaymen as distribute a large number of cards.

"Should the wording of the forecasts be confined to the vocabulary of the present logotype outfit?" I would most emphatically reply yes; and I would right here like to enter a protest against the forecast officials at Washington, or any forecast center, using any word in the regular forecast that is not in the logotype vocabulary.

Mr. Chappel. There is no doubt in my mind that the forecast official can improve his forecast and thereby benefit the public by having an increased vocabulary. Now the forecast official will use the words which come to his mind to express exact conditions, and from that point of view I would be in favor of increasing the vocabulary, but as our cards are distributed mainly by people not connected with the Bureau, receiving no pay, I would not approve of enlarging the vocabulary. If the forecasts were distributed from regular Weather Bureau stations, it would not make much difference, but as a great many more cards are sent out by voluntary displaymen than from regular stations, I do not favor increasing the vocabulary, but would confine the forecast official to the regular vocabulary.

Mr. Hammon. That is all right for a good part of the United States, but not for the whole. We need different vocabularies in different places. The present vocabulary fails to meet our needs in California, where much wider range of expression is necessary to accurately define the conditions predicted.

Mr. Chaffee. In connection with the logotype distribution of forecasts, I have found that it would be good if we could telegraph river forecasts to the river observers and let them disseminate the information in the same way we do our weather forecasts. In my river section in Alabama, in addition to the telegraphic distribution of flood warnings, such information is also widely distributed by mail, and has been of special benefit to farmers and stock raisers in the low grounds of the river basins.

Mr. Hackett thought it would be better to let each State specify its own vocabulary. Mr. Salisbury suggested that in the case of the State furnishing the vocabulary it could, perhaps, be furnished by the official in charge of the forecast center, who ought to know what kind of vocabulary he is going to use. The difficulty to be avoided is that the forecaster in charge of the forecast center has one vocabulary which he varies at his pleasure, but which does not correspond with the vocabulary furnished with the logotype outfit.

(*h*) *River and flood service.*

R. J. Hyatt, St. Louis, Mo., and L. M. Pindell, Chattanooga, Tenn.

Mr. Hyatt. The river and flood service of the Weather Bureau is of vital importance to a large portion of the people of the United States. By means of the river forecasts, flood warnings, and general information in regard to the stages of water along the principal streams, furnished by the Weather Bureau daily, the people are kept constantly posted in reference to the river conditions and make their calculations accordingly. During the periods of high water the most intense interest is shown in the river and flood service of the Government. At all river stations the office is besieged early and late by the public interested in the river, and all are more or less concerned in regard to the matter either directly or indirectly. The office telephone is kept busy answering calls and giving information to the public during flood period. At all times, however, the data is of great value and much sought by the public.

When the first warning note of impending high water is given by the Weather Bureau immediate preparations for the coming flood are made by the planters, levee boards, railroads, steamboats, and river interests generally. The levees are strengthened and raised if necessary; rafts are constructed and boats put in good condition for any emergency. Stock and other property are moved to places of known safety, such as mounds and highlands in the vicinity, in ample time in advance of the overflow. The people on lowlands subject to overflow naturally look to the Weather Bureau for protection and many precious lives and millions of property have been saved by the warnings issued from time to time. Planters when notified of an early freshet will defer planting until the danger has passed, thereby saving the cost of seed and labor. On the other hand if they know that the stage of water will not affect their land, they will plant an early crop and reap the benefit thereof. From time immemorial the great Father of Waters and his many branches have seen fit to throw off the yoke and go beyond all bounds, during certain seasons, and the ingenuity of man has so far been baffled in coping with the fury of the floods. The conditions, however, bad as they are at times, could be much worse; and during my observation of a number of floods I have always noticed some mitigating circumstances. A combination of high water in the Mississippi and all of its tributaries, in my opinion, has rarely if ever been witnessed, and the problem of controlling such a vast volume of water would be a very difficult one for the Government to solve. During the great flood of 1897, one of the most disastrous of record, I was stationed at Vicksburg, and the demands made upon the river and flood service of the Weather Bureau that year were enormous. Extra bulletins were called for at night and on Sundays in addition to the regular morning reports. The Government sent relief boats with ample provisions for those cut off by the flood from commercial centers, and camps were established for the destitute. The progressive policy of the Agricultural Department in recent years in giving the river forecasts and warnings the widest possible distribution is highly appreciated by the general public and much praise has been given the service by the many and varied interests involved.

The amount of passenger and freight traffic carried on the rivers is almost incalculable, and the river and flood service of the Weather

Bureau is considered a necessary adjunct to the successful prosecution of this important branch of commerce.

Mr. PINDELL. I have not prepared a paper, but have made a few notes which I will use to refresh my memory. I have also distributed copies of the Paper on the Tennessee River and Flood Systems around the room for the benefit of the officials present; the paper shows a study of over ten years of the local data. The benefit of the river and flood warnings to the people of my section is incalculable. It extends all the way from the head waters to below Florence, and we have received requests by telegraph for information from as far down as Paducah. We have given from thirty-six to forty-eight hours warning as far down as Bridgeport, and in the flood of 1897 all the property lost that I could hear of as far down as Florence, Ala., did not exceed $100. The people in Chattanooga and the surrounding districts rely implicitly on the river warnings given by the United States Weather Bureau. When the Tennessee River reaches 36 feet, readings are taken every half hour and given to the public, for the reason that the water backs into Chattanooga and Chickamauga Creeks, overflows their banks, and forces the people to move out. Thirty-seven families one day awaited an inch more of rise in the water before they would have to move; I told them not to go and promised them thirty-six hours notice, and they were not compelled to move. We have one station on the Hiwassee River which only reports six months in the year; I think that all our river stations should report all the year round. On the Little Tennessee we have no station, and I would like to see one established there. Our river service could be improved by telegraphing daily to certain places desiring river forecasts. As it is now, some of them wait until the river commences to rise and then telegraph Chattanooga for the forecasts.

The rainfall observers should be authorized to telegraph the rainfall whenever it equals or exceeds one-half an inch. It frequently happens that between .90 and .98 of an inch of rain falls for two and three days at these stations and they make no report, consequently the river forecast falls short on the crest rise predicted. The code of the river system could be decidedly improved. I would suggest that the code words in our regular code signal be substituted for those now used in the river code. That would save in telegrams and time of translating. Our river men are as much, if not more, interested in low water than high water from the fact that they only look after and protect their property in high water, while in low water they do most of their business, and if they knew the stages at each river station they could readily decide how to load their barges and boats for safe passage over the sand bars, rocks, etc., that are yet in the channel. For this reason river stations should report the entire year. The lumber interest on the Little Tennessee River is practically unprovided for, there being only a rainfall station at Bryson City, N. C., on the head waters. A river station should be established within 50 miles of the mouth of this river. To better improve the service, every river and rainfall station should be visited by the official in charge of the center at least once every two years, as changes are frequently made and it is impossible to get some of these observers to understand by correspondence exactly what is required and wanted.

If the official and the observers knew each other personally, better work and more prompt service would result.

Mr. MARBURY. I have noticed that in all the papers that have been brought forward the importance of low water has been underrated. For a long time it has been acknowledged that water is our cheapest source of power, and no capitalist is willing to subscribe money for the erection of a factory unless he knows positively that a certain stream of water can be depended upon the year round to furnish power. I know this from an instance that occurred in Atlanta not long ago. There had been no official record kept of the section where they contemplated establishing this plant, consequently they removed about one hundred miles lower down, where we had river observations for ten years back, which established beyond doubt, that they could depend upon a certain amount of water. They have now established a power plant at Columbus, Ga., which will probably run all the electric plants in that city. It seems to me that it is important to keep ourselves posted and keep the river stations open the year round, in order that we may know what low water is, and also that we should work in conjunction with the hydrographic department of the geological surveys of the States. They take these measurements, showing the amount of water passing at certain stages; we take the amount of rainfall; from these data as a basis we can determine the amount of evaporation, the amount of percolation, and the amount that passes off. These records will be of untold value in future years—fully as valuable as the records of floods. I think we should have the observations continued the year round, not so much for predictions as for record. This information is being called for more and more each year.

It is now acknowledged that cotton goods can be manufactured cheaper in the south than anywhere else. Why? Because with our water power near the cotton fields, factories can be, some already have been, located on these favorable spots, and the greater portion of our cotton crop shipped in the form of manufactured goods. Eastern capitalists, seeing this possibility, are already beginning to investigate our region with a real desire of finding out more about it. Now we want to be able to furnish officially the exact condition of our rivers for each day of the year, the low as well as the high water stages, the former being by far more important in this connection than the latter. Power plants can be so constructed as to take care of themselves in high water if it is assured that they will always have the required flow for power.

Mr. Sims suggested that the flow line might be shown on a blackboard placed on the paddle boxes of steamers, or on the casing of a stern-wheel boat, so that the boat in passing would show exactly how

the river stood, the official in charge of a division of a river to place the drawing on a board for the section covered on the up or down trip of the boat.

(i) Should warning messages (Form 1043 C) be of some distinctive color to more readily attract attention?

S. W. Glenn, Huron, S. Dak., and T. B. Jennings, Topeka, Kans.

Mr. Glenn. The Form 1043 C now in use is the same color as the daily mail forecast card, and there is nothing to distinguish it from that card and indicate its greater importance to the public but the printed descriptive matter on it. To the person who daily inspects the forecast cards this is sufficient, but there are many interests, at least in South Dakota, not materially affected by ordinary changes in weather and temperature, to which cold wave or norther warnings are, or might be, of importance and benefit. If Forms 1043 C were of some distinctive color, they would more promptly and generally attract the attention of the masses, and thereby prove of universal value. In South Dakota and probably much of the Northwest there are live stock, creamery, and probably other interests not specially benefited by the ordinary forecasts to which, in many localities, the cold wave and norther warnings are of great importance. Many farmers in South Dakota hasten from the towns to their homes when they see these warnings to provide against loss or damage, and the number would probably be greater if the color of Form 1043 C was such as to attract special attention. It has been found that Railway Mail Service clerks are frequently asked at depots what the weather forecast is. A card of a distinctive color for warnings would at a glance put the clerk in possession of weather information of importance to the public which might otherwise escape his attention, and he would find interest in disseminating information of such importance wherever possible, especially to railway employees and habitues of depots. The postmaster, if hurried, may neglect to post the ordinary mail forecast card in its bulletin board until the entire local mail is distributed; if the card was of a distinctive color to indicate its importance as a warning, it would immediately attract attention, and its importance to the public would no doubt cause him to give it publicity immediately. The norther and severe cold-wave warnings are of such importance to the railways of the Northwest that the assistant superintendent of the Chicago and Northwestern Railway at Huron has agreed to disseminate them by telegraph to agents of the entire system in South Dakota, when practicable, without expense to the Government. They are of such importance to the masses that I am satisfied the adoption of Form 1043 C of a distinctive color for each class of warnings, different from the color of the ordinary daily forecast cards, would be of more benefit to the public generally, and more promptly and generally disseminate the information than the form now in use for the purpose. In the case of cold waves, they could take the place of the present Form 1044–Met'l to advantage by facilitating local distribution. The public could very readily be instructed as to the significance of the cards of different colors.

Mr. Jennings. In 1871 the Signal Service, in addition to the regular "probabilities," adopted a special flag to warn mariners of the

approach of storms. The importance of this flag soon became so prominent that vessels leaving port during its display forfeited their insurance. In 1884 a white flag with a black center was adopted as the special warning of the approach of cold waves, and the importance of this flag in the interior soon became as pronounced as that of the storm flag on the coast, so that to-day the forecast may contain the announcement of a cold wave without causing much more than a ripple in the public current, but fly the cold-wave flag to the breeze and note the change. Now all is bustle; the cattle man looks after his herds; fruit in transmission receives extra care; the farmer hastens home to care for his stock; the produce and commission merchants take extra precautions; and so I might name nearly every industry.

If a distinctive flag is so important on the coast with reference to storms, or over the whole country with reference to cold waves, how much more important is it that Form 1043 C, which combines both and reaches hundreds where the flag reaches one, should be distinctive.

What this distinction should be I confess I am not prepared to state, but believe that a distinctive color would best subserve the end; yet it should be a color that would not interfere with the legibility of the ink used. Such a card would soon become more widely prominent and better known than either of the flags, so that when posted the news would soon spread over the town and through the surrounding country, "the red card is out and a cold wave is coming," or "look out for twisters," as the case might be.

It is very desirable, I might say imperative, that Form 1043 C be distinctive.

TOPIC No. 3.—PAPER: RELATION OF THE WEATHER BUREAU TO THE DEPARTMENT OF AGRICULTURE.

E. B. Calvert, Washington, D. C.

Mr. Calvert. There are three things, more than any other, upon which the prosperity of a nation depends: its climate, agricultural products, and mineral deposits. It is difficult to conceive of a progressive and wealthy nation without these natural resources. The products of the soil and the earth beneath the soil give life to the people and are the basis of commerce and manufactures. But however rich a land may be in soil and minerals it can not reach its fullest development unless the climate of that land is favorable. In our own United States we have all the conditions for a prosperous nation.

> Nature was here so lavish of her store,
> That she bestowed until she could bestow no more.

The work of the Weather Bureau is so closely interwoven with two of the great factors of prosperity that we have named, climatology and agriculture, that one can not be considered without the other. If the climatology of a section is accurately determined, the scientific agriculturist knows what crop the lands will bring forth in greatest abundance. Experience has been called our great teacher, but something else is required of the successful agriculturist. He must get close to nature and learn her secrets. It is not sufficient for him to know that a certain piece of land produces an abundance of one kind

of grain, while another farm product can not be grown thereon. He must know why these things are so; he must understand the composition of the soil he cultivates, how much rain annually falls on his possessions and the movement of this moisture in the soil; he must be familiar with the nature of the economic plants, the plant foods required in growing and maturing them, and the amount of moisture and sunshine necessary for perfect maturity. Climatology is surely a part of agriculture.

The United States has a Department of Agriculture, the most complete in the world; and at its head is a practical farmer, a scientific farmer—one who has guided the plow as the furrows were turned, and one who has studied the science of agriculture in Nature's laboratory, as well as in his own. Under him serve what Sir Richard Armstrong, of England, declares to be the ablest aggregation of agricultural scientists to be found anywhere in the universe.

The home seeker obtains from the Weather Bureau information as to the climate of any State or county in which he wishes to locate; the divisions of soil and chemistry inform him as to the nature of the land he will cultivate and what crops will best thrive thereon; the botanist and vegetable pathologist name the flora and the diseases to which plants are subject, and give a remedy for them; the agrostologist advises him as to the grasses to be sown for feeding his flocks; and the Departmental publications keep him abreast of the arts and science of farm work as it expands and develops. The Department of Agriculture is an intellectual monument of which the people can be justly proud—a monument built of divisions and bureaus whose functions are separate and useful, yet working together in one harmonious whole. The Weather Bureau is a part of this grand monument. A portion of its work necessarily has only a remote connection with agriculture, but along certain lines its identity with the Department is clearly established. This is particularly true in regard to climatology and its climate and crop work. The botanist, biologist, agrostologist, agricultural chemist, and soil physicist, all understand and appreciate its value. It is just as necessary for the Weather Bureau, through its section directors of the State Climate and Crop Services, to have a certain knowledge of the work done by these scientists as it is for them to understand something about climatology. The section director is better fitted to intelligently report on the crops of which he writes if he understands these things. It is all a part of his work. He can aid the soil physicist, botanist, and chemist, while they in turn impart to him useful knowledge. A successful forecaster in the Weather Bureau, in addition to his knowledge gained by experience and empirical reasoning, must know the physical laws connected with the meteorological conditions he foretells. Just so, the section director, in addition to his skill as an executive and his ability as an organizer, should understand the principles of agricultural chemistry, and the physical requirements of the staple crops. This knowledge raises him above the plane of a mechanical worker to the eminence of a practical scientist and student. The climatological and agricultural field is large. Our knowledge of it is but as a grain of sand on the ocean shores, compared to that which has not yet been acquired by man. But Nature holds her secrets with jealous care. She only reveals her jewels to those who with concentration of physical and mental energies earnestly dig down into her depths.

There is legitimate work in this line to be done. It behooves the officials of the Weather Bureau to remember that we are but an integral part of a great Department, and that we should become acquainted with the aims, objects, and developments of the other branches to the end that we may grow together, one assisting the other, into a perfect organization.

TOPIC No. 4.—WEST INDIAN HURRICANE SERVICE.

Prof. WILLIS L. MOORE, Washington, D. C.

Professor Moore spoke briefly on the West Indian Hurricane Service as follows:

The West India region, which includes an area as large as the United States, is to-day brought twice daily under an atmospheric survey that will enable us in the future, as it has in two cases recently, to detect the development of the most destructive storms that visit our continent; to measure them in their inception, to keep pace with them as they cross the Windward Islands and come up through the Caribbean Sea to the Gulf of Mexico, and to do what has been the dream of the meteorologists of England and other scientists for a great many years—to warn the commerce of all nations in that great region against hurricanes. It was a singular thing that this year no hurricane passed over the Antilles until several weeks after the beginning of the usual hurricane season. Providence seemed to be on the side of those who fought against the oppressors of humanity. Our fleet was able to leave those waters without encountering a storm that even incommoded it. Soon after its departure there came a most destructive storm; one in which it seemed that the force of all the storms that should have developed in the preceding weeks was gathered and centered. It seemed that nature was keeping up the average and establishing the equilibrium by letting the winds burst in one terrific hurricane after the American fleet had sailed north.

I wish to call attention to the warnings issued in advance of that great storm; they could not have been more advantageously displayed in the interest of the mariner had we possessed absolute foreknowledge of the development and severity of the storm.

TOPIC No. 5.—POSSIBILITIES OF THE WEATHER SERVICE ON THE PACIFIC COAST. VALUE OF MOUNT TAMALPAIS OBSERVATIONS.

W. H. HAMMON, San Francisco, Cal., and B. S. PAGUE, Portland, Oreg.

Professor MOORE. We will now hear from Mr. Hammon as to the possibilities of making seasonal forecasts of rainfall for the Pacific Coast States.

Mr. HAMMON. I think what Professor Moore refers to is a paper on the Rainfall of California and the Weather of the Aleutian Islands, which he requested me to present here, but which I do not think it feasible to read in detail. It really belongs more in the line of long-

range forecasting. I want to say just a word in presenting the paper, and ask that it be referred to some committee for consideration.

Conditions on our coast are quite uniform, with once in a while, and at long intervals, marked exceptions. Four times in the last half century we have had one-half, or less than one-half the normal rainfall in California. It struck me that such conditions must be associated with marked conditions elsewhere as a cause. In searching for these I found that when the conditions are abnormally warm at Unga Island, Alaska, where we have a voluntary observer, then three months later the rainfall in California is abnormally light, and when the conditions there are cold, the rainfall here is excessive. I searched for further information, and found records at some four or five islands, taken by agents of the Alaska Commercial Company. The records are not very well taken; some of them by Indians. Some ran for three years, some for ten. The aggregate number of years is about twenty-five, and together they cover a period of thirteen years. Using the hypothesis based on the first four years' record, and testing it by these other records, I found that 74 per cent of the abnormal rainfall in California was preceded, for a 3-months period, by abnormal temperature conditions on the Aleutian Islands; that is, when it was warm up there there was light rainfall, according to the rule, three months later in California, and *vice versa*. The original Unga Island records made 79 per cent. I have all the facts and papers in this connection with me, and I suggest that a committee be appointed to consider the matter and ascertain whether there is anything in it. The people on the Pacific coast would be glad to have the matter receive attention here and have some action taken. On the general subject assigned me I submit the following:

Owing to the reputation for exaggeration which eastern people have unjustly accredited to residents of the "Golden West," I hesitate to speak *facts* before even so well informed a body on climatic matters as this Convention. To give to the imagination that play the subject warrants would be but to court incredulity.

The Pacific coast is peculiarly a region of climatic extremes. It is the region where may be found the places of maximum and almost minimum rainfall and the highest and nearly the lowest temperatures for the entire United States. Places with mean annual rainfall as low as 3 inches may have floods that will annihilate towns and wash away miles of railroad track. In certain counties exist living glaciers and also temperatures above the limit of human endurance. The vegetable products are, of course, as varied as the climate. On the Sierra are places where even the red snow plant will not grow, and yet 50 miles away palms flourish in profusion and alfalfa yields six crops a year. Surely a region with so varied climatic conditions and so many resultant industries must be a field where the Weather Bureau can do a valuable work.

The Pacific coast is recognized as one of the great wheat-producing regions of the United States. Over a large portion of this region

there is sometimes insufficient rainfall. At times, on such occasions, a rain forecast will change the price of wheat several cents per bushel. Portions of the most productive regions are in the vast river bottoms, which are subject to overflow in times of excessive rainfall, with consequent loss of entire crop. At other times frosts and again dessicating "northers" do marked injury.

Should the suggestion outlined in another paper as to the possible relationship between temperature conditions in the Aleutian Archipelago and rainfall on the Pacific coast prove to be a fact, and the ability result therefrom to make forecasts of abnormal rainfall two or three months in advance, as now seems possible, the profits to the grain industry will be more than doubled.

What is said of wheat is still more true of barley, which, being more of a local crop, has the price much more affected by local conditions. Two years ago about one-third of the entire crop of barley raised in the United States was grown in California. The failure of the crop during the past season increased the price in that State 300 per cent. One of the largest growers and commission merchants on the San Francisco Produce Exchange failed because a telegraph operator mistook an "s" for an "l" in the cipher report from Eureka, thus changing a northwest-wind word to that for half an inch of rainfall at that point.

But it is in fruit industries that the Weather Bureau can be of greatest benefit. In no other section of the United States are there so varied or extensive orchard industries, and the present is merely a forerunner of what may be expected, in a much more marked degree, in the future. Reference is made especially to California and portions of Arizona with which the writer is familiar. With the improved transportation facilities now in sight and the reduction in freights which will result from competition, the excellence of its products, the extent of the industry, and the effects of its competition will surprise the whole world. Without the warnings of the Weather Bureau many of the fruit industries would never have reached their present magnitude, and their future extension will in a considerable measure depend upon the aid rendered by this service.

All have doubtless heard of the work that has been done in warning raisin and prune driers of the infrequent summer rains which do such serious damage to the unprotected crop. With the generous use of the telephone and telegraph and the cordial co-operation of the railroads information useful to the forecaster is received as desired; warnings are delayed until he is practically certain of the result, and then distributed in such a wholesale fashion that almost every drier in the affected region will receive the warning in an hour from the time it is issued. This line of work has reached such a degree of excellence that but little further improvement is expected or needed. Hardly a single failure in the warnings has been noted in the past five seasons. Single warnings have been of more value than the annual cost of the entire Pacific coast service.

The chief enemy to all lines of fruit industry, however, is frost. The temperatures in the principal fruit growing districts of California are somewhat peculiar from the fact that while, at no time in the year, are air temperatures below 24° to 26° to be expected, and the absolute minima ever recorded are but 5° or 6° lower, yet frosty conditions are likely to occur at any time from November to April, in-

clusive. Probably never a year passes when the losses from frost do not exceed the profits or, in other words, the profits would have been doubled had the injury from frost been prevented. To prevent this loss it is necessary that the fruit grower be taught *how* to protect his crop, as well as informed *when* frost is likely to occur. In this particular I believe the people of the Pacific coast, especially the orange growers of southern California, are perhaps better informed than in most other portions of our country, but decidedly more instruction is necessary. Not only should articles be written and phamplets issued on this subject, but it is necessary if possible to give personal instruction to the grower. This topic should be one of the leading ones to be discussed at the farmers institutes now so generally conducted throughout the country.

It has been possible to forecast frosts in a fairly satisfactory manner for a considerable time, but owing to the very generous treatment of the Pacific coast by the Department of Agriculture and the present Chief of our Bureau this year, a decided advance in the accuracy of these forecasts is expected. Several years ago it was observed that the cool waves of the Pacific coast followed the movements southward of a wave of falling pressure. I think the Chief of the Bureau observed this condition first with reference to cold waves in Wyoming and Colorado. It has been possible to follow these pressure waves as they moved southward through Idaho and until they passed Winnemucca and Salt Lake City. From the time they passed those stations, however, they were lost sight of until they appeared with their frosty effects in California and Arizona. In fact as good, and perhaps better, frost forecasts were possible for that region thirty-six and forty-eight hours in advance than could be made for a shorter period. The opening of several stations in the Transrocky Mountain region will be of great value in frost predicting.

The station recently established on Mount Tamalpais, near San Francisco, is another great aid to frost forecasting. Among many other benefits expected from that station may be mentioned the fact that every marked temperature change which has occurred in California and the Plateau region to the eastward during the past year has been preceded about twenty-four hours by a falling temperature upon the mountains. I am unable to give a satisfactory explanation of this phenomenon, but its occurrence has been so frequent as to leave no room for doubt as to the fact. The place is also an ideal point for weather observations. At San Francisco, for six months of the year, there is a large portion of the time that the observing station is immersed in a local fog with west wind, and to a less degree this is true during the other six months. The station on the summit, half a mile above the sea, and three or four miles from the coast, is above all these disturbing influences. Gales on the mountain are due to general cyclonic disturbances and are an indication of rain. Observations at this station I think have already shown quite conclusively the cause of the fogs of the Pacific coast.

It has brought to light many facts of interest to the meteorologist, one of the most striking being the marked temperature inversion between the mountain top and the valley. During the summer the temperature on the mountain averages more than 10° higher than in the valley.

The station is being equipped as a complete self-registering observa-

tory. It is connected with the San Francisco office by both telephone and telegraph, and through it is therefore in immediate connection with the city telephone exchange and the Western Union telegraph office. The observatory building is a convenient 8-room cottage, and has besides office rooms, living quarters for the observer and rooms for the forecast official when he deems it advisable to be upon the mountain and make and issue forecasts therefrom.

But not alone to the agricultural interests of the Pacific coast is or can the Weather Bureau be useful. Throughout the entire coast region from Alaska to South America vast mining operations are carried on. In hydraulic mining, hills are washed away by the force of water power. River bottoms and immense tracts of bottom-lands are scooped up by huge steam dredges, the gravel washed, and the refuse dumped out behind. In all such enterprises information of sudden rises in the stream and of snow in the mountains is of great value.

One of the great drawbacks of at least the south portion of the Pacific coast, in an industrial way, has been the extremely high price of fuel, and the consequent expense of power for manufacturing enterprises. Bituminous coal costs in California from two to three times as much as anthracite does in Pennsylvania. Within the past few years several expensive enterprises have been put in operation for utilizing the water power of mountain streams to run electric dynamos. The electric power thus obtained is carried in high potential currents to cities many miles away, where it is used for manufacturing purposes, to operate street cars, electric lighting, etc. The records of rain and snowfall are eagerly sought by the promoters of these enterprises to determine the probable minimum discharge of the various streams. Warnings of freshets and floods are also much desired.

Similar information is sought by the companies conducting vast irrigating operations, which are causing the deserts in portions of the arid regions "to blossom as the rose."

As yet no mention has been made of the marine industries and the study of climatic conditions, since these are already more clearly understood. In few, if any, sections of the world is there such a variety of climate within the same limits, and it is difficult for people not on the ground fully to understand these conditions and their needs. More instruments, more records, and more study is necessary to properly determine the conditions of Tulare and Inyo counties of California than is necessary in the whole of vast States in the interior valleys of this continent.

Probably no branch of the work of the Bureau on the Pacific coast is so imperfectly and unsatisfactorily performed as that which touches the marine interests. With no observations from the west and with ports at "magnificent distances" apart, storms appear on the ocean which for severity are seldom if ever equaled on the Atlantic. The Pacific is a sad misnomer to that portion of the ocean north of the fortieth degree of latitude, a fact not appreciated by the great majority of the people. The disasters which occur in that ocean in proportion to the vessels engaged are not equaled elsewhere. Vessels at sea feel the effects of these storms before the evidences of them are visible on the coast, and it is only at times that vessels about to leave port can be forewarned in time.

When commercial and industrial enterprises render telegraphic

communication with the Aleutian Islands necessary, or some man of foresight sees that these lie on the shortest route, offering numerous islands for landing places, making this the most feasible route for connecting the United States with the Orient and her recently acquired or expected possessions in the Philippines, then will a new era arise in the work of the weather service on the Pacific coast. Of course such a connection is not to be thought of for Weather Bureau purposes alone, although its benefits might annually approximate its cost.

With the station on Mount Tamalpais multiplied many times on the Cascades, Sierra, and Coast Ranges, and with observatories established on Ranier, Shasta, and Whitney, even in the upper half of the atmosphere, then these mountain chains which now so confuse the forecaster may, and I believe will, become his greatest helpers. During the present administration this long neglected section has received most generous treatment, but similar munificence must mark the actions of Congress and the executive officers of the Department of Agriculture and the Weather Bureau for some years to come. I believe the Pacific coast is the ideal field for Weather Bureau work, and when the work of that section is placed in the prime condition that the not far distant future will find it, then, if not before, it will be found, what already I can dimly see, *that the key to accurate forecasting in the East lies in the weather conditions observed on the Pacific coast.* Every dollar spent in improving the work there means many dollars saved by improved warnings to the eastward. We are all a part of one vast service operated for the benefit of an extensive and rapidly broadening country in which an improvement of one section means a general advance, but in an especial and peculiar manner does the development of our work to the westward mean a resulting decided advantage to the region to the eastward.

Professor Moore (referring to the rain warnings for the raisin-growing district in California) asked if the topography of the country accounted for the accuracy with which forecasts of rain could be made.

Mr. Hammon. The first point is this, that we wait until we know what is going to happen, and then the railroad, telegraph, and telephone companies let us use their lines to any extent we desire. We can get reports every hour if we wish. We have never given less than six hours warning, and have given as high as twenty-four hours. We never give it until we are sure. We have never sent a warning into the valley that has not been verified. There have been some thirty or forty sent in since I have been on the Pacific coast. The people depend upon them absolutely. Within one hour I can distribute throughout the whole raisin-growing section a warning that will reach almost every grower. There are about sixty blue (rain) flags in that section. We use the telephone, and the exchanges warn every individual over the telephone. These sixty displaymen run up their blue flags, and in one hour it is done.

Professor Moore. It has been the dream of meteorologists for all time, or at least since cyclonic storms began to be studied, to forecast the weather months or seasons in advance. So far it has not been possible to attain that desired object. I wish to state in this Convention that we do not believe that any man to-day can foretell the weather one month in advance. We believe there is not a shadow of scientific basis for any such prediction; we believe that any long-range forecaster, unless perhaps he be in India, is a fraud and a charlatan. If there were any basis for such predictions, surely we would make use of that knowledge.

Now, I am not discouraged in hoping that the time will come when we may make long-range forecasts. What a wonderful conservation of human energy would result were we able to say to the cotton-grower, "Cotton will be favored next year;" or to the corn and wheat raisers, "You can cultivate prodigiously, for Nature will be bountiful next season!" If the knowledge necessary to make these forecasts ever comes, it will result from a comprehensive study along strictly scientific lines of the great mass of data we have been collecting over a broad area for the past twenty-seven years. No other country in the world has such an extensive area right in the very track of storms, in the middle latitudes, that is twice daily brought under a synoptic weather survey. We, possibly, are collecting data which will be of vast utility to the coming civilization, and which will be an important factor in the development of that civilization. This country is leading the world in this study, as it is leading it in a great many other things. It has occurred to me that the civilizations that have come from the north temperate zones have been the civilizations that have endured. When they have reached a high degree of cultivation, they have not become weakened by luxury and gone down to decay like the civilizations of the ancient Egyptians, the Assyrians, the Babylonians, the Medes and Persians, the Greeks, and the Romans. We have made a civilization that has never halted; and from the present indications the Northmen, meaning the men of the north temperate zones, will dominate the earth. And their power comes more from climatic conditions than from geographic situation.

I may be digressing a little, but this civilization of which I am talking is being brought about by the study of just such great problems as you men are engaged upon to-day, and this problem of long-range forecasting is a very important one. Mr. Hammon has made a very intelligent study and it demands our attention. It means a great deal if we can foresee for the Pacific coast the rainfall for the coming season. I will appoint as a committee to take his paper on the rainfall of California, etc., and carefully digest it for final report to the Chief of the Bureau, Professors Abbe and Hazen, Mr. J. War-

ren Smith, Mr. Cox, and Mr. Salisbury. I would like to get the opinions of these gentlemen in writing for final consideration. In this connection I want to say that Mr. Hammon is entitled to a great deal of credit for the method he has employed to bring out the facts and open a discussion which may blaze a way that will lead to important results on the Pacific coast. We wish to hear from Mr. Pague on this same subject. He has made a most intelligent study of the peculiar types of barometric distribution that bring rain on the north Pacific coast. He has been a long time in the region, and has brought his services to a high degree of efficiency. He needs no further introduction from me.

Mr. PAGUE. Before taking up the "Possibilities of the weather service on the Pacific coast," it might be well to stop a moment and consider the peculiar conditions that obtain there. They are peculiar from two points of view, meteorologic and topographic. We have, from the meteorologic standpoint, an immense area of high pressure off the southwestern California coast, which has a slight movement from winter to summer and from summer to winter, north and south. We have over Arizona, portions of California, Nevada, and Utah, a region of low pressure, present in summer and not so distinct in winter, although present to a certain extent over southern California and Arizona. We have a permanent low pressure over what we are pleased to call Tatoosh Island, more specifically described as off the northwestern coast of Washington, and off the British Columbia coast. This area of low pressure, or permanent low, is present from the time we are pleased to call the winter storm conditions until their disappearance the following spring. Possibly we shall determine the origin and entire movement of these lows when we have a system of telegraphic reports stretching from the Philippines to Japan and thence to China, the Russian coast, along the Aleutian Islands to Alaska and finally down to the Pacific northwest. We shall not be able to increase the accuracy of our forecasts to any great extent, nor shall we be enabled to make them for a greater period than we do now, until we have amore thorough system of reports on the north, northwest, and partially to the northeast.

Our storms in winter, from the observations at hand, are first shown off the British Columbian coast. I presume that these areas of low pressure come from the China sea, move along the Aleutian Archipelago, thence along the western coast of North America to about latitude 50° north, where they have a permanent home and a pathway for passage eastward. A few of them are deflected southward along the coast; in the last five or six years several of these areas of low pressure moved southward past Cape Mendocino over California to Arizona and thence northeastward, giving to the eastern portion of the country the most severe storms of that period. These we are pleased to term erratic lows. The low in its regular course moves to about the latitude of Puget Sound, passes eastward about Spokane, north to Alberta and thence toward the Great Lakes; while the area of low pressure is doing this, the high pressure comes in from the southwest, evidently from the immense area of high pressure already referred to, moves from Cape Mendocino to Salt Lake City,

giving to that region an area of high pressure. These are two distinct types of weather we have in our winter season.

In summer we have areas of high pressure which, instead of moving eastward to Salt Lake City, or Southern Idaho, move northward to about 50° north latitude, thence passing eastward. The lows in summer, instead of moving along the western shores of our continent, cross the Rocky Mountains about the latitude of Sitka and come down on the eastern side of the Rockies.

The foregoing are well-defined movements, and on these movements forecasts for greater or shorter periods are possible. I agree with our chairman that long range forecasts are not to be recognized by the Bureau, and that the individuals making them have no standing, but at the same time I want to impress upon the officials of the Weather Bureau here present that we can and do make seasonal forecasts for the north Pacific region which, for the past five years, have yet to be found lacking in a single character for verification. Possibly we can make them more specific in time; we hope so, through the work on which Mr. Hammon is now engaged. Whenever it is found that an area of low pressure comes down along the coast in the autumn, becomes central about Tatoosh Island, we find coincident with that an area of high pressure moving not much farther north than Cape Mendocino, and then due east to Utah, when these conditions are present, then we announce the first winter storm conditions and from that time until the appearance of summer weather conditions next spring, we may expect more rain than fair weather. That is what I am pleased to term a long-range seasonal forecast. That marks the commencement of our rainy season, and yet we don't mean that it will rain all the time, simply that the conditions are more favorable for rain.

Conditions that produce rain in winter will not produce it in summer, and the contrary is also true. In the spring of the year, when we find the high pressure moving northward along the coast to the Columbia River and farther northward to Puget Sound, and an area of low pressure does not appear west of the mountains, we announce that the summer conditions have arrived, and that from then to the commencement of the winter conditions in the autumn, we shall have greater probability for fair weather than for rain. These are general statements, but they are of benefit to the farmer. Many farmers of the Pacific northwest write, and many make personal inquiries, asking whether our rainy season has commenced. They want to know so as to determine whether to begin plowing. Many merchants and many builders ask the same question. So that while the forecast is very general in its terms, its benefits appear on its face, and the same is true of the summer conditions in spring. Many a dealer in wheat asks as to the possibilities for more rain during May and June. We have in the Pacific northwest a country larger in area and richer in resources than many of you have any idea. We have one river, the Columbia, which drains a region approximating one-quarter million square miles; and we have others besides. In that region we have immense wheat fields, that produce from twenty to fifty or sixty bushels per acre, with less than 20 inches of rainfall annually. We have immense timber resources; immense areas devoted to wheat, to hops, and to many other products peculiar to the north temperate zone. All these are affected directly and in-

directly by the Weather Bureau forecasts and warnings. We have an immense coast line and immense shipping. Our trade goes to Russia, China, Japan, the Sandwich Islands and the Philippines, to the South American coasts and around the Horn to the Atlantic side and to Europe. So we must have accurate forecasts, that our ships in leaving the harbors of the Northwest may be enabled to pass outward with assurance of fair winds to start on their long voyages.

Our forecasts cover quite a number of industries. Fortunately the Weather Bureau has a system of telegraph lines extending westward to the capes, so that the storm signals ordered up from Portland are quickly transferred to the various ports of the sound and thence down the straits, so that a ship may stop within five miles of the ocean itself. It is no unusual thing to get requests from consignors or captains for information as to whether their ships may sail. The Columbia River runs 13 miles north of Portland, and through the center of the city flows the Willamette; vessels load in Portland to 23 feet, proceed down the Willamette to the Columbia and thence to sea. Ships going down stop at Astoria, and it is somewhat unusual for a single day to pass without our receiving requests from owners or consignors for information as to whether their ships can pass out.

The Willamette River has its rise in winter, due to melting snow in the Coast and Cascade mountains; the Columbia has its rise in June, due to melting of snow in the Rocky Mountains. The rise in the Willamette is quick, and sometimes very decisive. The river is 150 miles long, and it is sometimes very difficult to give warning for the benefit of the merchants in the city of Portland. The river has but a slight rise to make before the lowest docks are covered. With the rise of the Columbia in June the Willamette can not flow, and hence we have backwater in Portland; we have had 33 feet. In these river forecasts the merchants along the river front will telephone us and say, for example, "We have 4 inches to go upon; shall we move our goods?" If we say no, they leave them; if they have a foot to go upon and we advise them to move their goods, they do it. One hundred thousand to half a million dollars are saved every year by our river forecasts alone.

It is doubtful if any other portion of the United States offers greater possibilities for the weather service than the Pacific coast. The acquisition of new territory in the Pacific, the development of Alaska, and the consequent development of the transmountain States on the Pacific, opens a broad field for the weather service. The good work of the Weather Bureau in the east in connection with the satisfactory work on the coast causes the coast people and those settling among us, who come from the east, to look to the Bureau for much assistance. New lines of steamships are starting from every port; the grain fleet is rapidly increasing; the flour and lumber trade with Siberia and the Orient is very large and it is just commencing, so that there is a large and growing field for the Weather Bureau in the shipping interests of this coast.

The fruit, grain, vegetable, hay, hop, and fishing interests are large and rapidly growing, and in these interests there are many avenues in which the Bureau can be of value. The mining interests are second to none, and as they depend to a very large extent upon the water supply, the value of forecasts and data is apparent. The stock interests represent millions of dollars, and the forecasts and data are

very valuable. It is unnecessary to outline the various means used to serve these interests, for they are familiar to the Weather Bureau official; sufficient to state that they are now large and growing interests, and to cope with them the Weather Bureau must expand and be alert. It has kept pace with all necessities in the past and promises to be equal to or ahead of them in the future.

The river forecast work is second to no other feature of Weather Bureau work on the coast. River forecasts depend upon weather forecasts; an error in one usually results in an error in the other, for melting snow, as a rule, causes the rivers to rise, and upon the temperature and weather conditions the snows remain or melt. The accuracy and value of the river forecast work has frequently been shown by official reports on this subject; sufficient here to state that there is official knowledge of one month's river forecast saving $240,500 in the city of Portland alone.

The work of the climate and crop service is of great importance. The furnishing of data for physicians, investors, and for immigration purposes is valuable to the people. There are so many ways for the Bureau to aid the public, to grow and develop, on the Pacific coast, that it would become tedious to enumerate them all; sufficient have no doubt been mentioned to illustrate the breadth of the practical work of the Bureau on the coast.

The great need and desire is to furnish more accurate forecasts and for a longer period of time. As our chairman has stated, it has been the dream of meteorologists for all time to forecast the weather for months or seasons in advance, and a study of the meteorology of the Pacific, from the Arctic regions to the equator, from the eastern shore of the Pacific to the western, will, in my opinion, materially assist and possibly accomplish this great desire. The influence of the barometric conditions, arising in the Pacific, extends in a large percentage of cases, if not in all, to the weather conditions east of the Rocky Mountains.

A study of the causes producing, at times, peculiar meteorological phenomena will aid the eastern forecaster as well as those of this coast. This is the great possibility of the Weather Bureau on this coast, but it can not be accomplished until the telegraph lines and observation stations are extended, and the whole coast to the farthermost island of the Aleutian Archipelago, the eastern shores of the Orient, and the islands of the Pacific are brought under the present twice-daily atmospheric survey, as is the case in the United States proper.

In the pamphlet prepared by my colaborer, Mr. Blandford, and myself, and issued one year ago, entitled Weather Forecasting and Weather Types on the North Pacific Slope, the regular movement of the area of high and low air pressure and the resulting weather are discussed. This pamphlet touches upon the subject of long-range forecasts and briefly outlines how the idea can be enlarged and improved upon. Owing to the well-defined movement of the barometric area on the Pacific slope, I am of the opinion that there is the place where long-range forecasting can be taken up. Causes producing the movements must first be studied; then the effects can be forecast. The present development of the Weather Bureau is rapid, and under the impetus that it now has I am hopeful that my great desire for long-range forecasts will be realized, thus benefiting man-

kind and developing the greatest possibilities of the Weather Bureau on the Pacific coast.

TOPIC No. 6.—PAPER: SOME RAIN PRODUCING PROCESSES.

Prof. E. B. Garriott, Washington, D. C.

As the capacity of air for moisture is increased with rising temperature it is evident that rain or snow can not fall from air that is growing warmer; and yet, paradoxical as the statement may appear, rain usually begins and snow commonly falls with rising temperature. Nevertheless the fact as first stated holds good, for in the upper regions of the air, where the water vapor is actually condensed into rain or snow, certain processes are developed which are not appreciable at the surface of the earth.

The development of one of these processes is dependent upon the warming of the lower air which, in a general way, is accomplished by the radiation of the sun's heat from the earth's surface, a constant operation which is especially active in fair or cloudless weather. In the rain and snow producing processes referred to, however, the warming of the lower air is effected mainly by a northward flow of air having the temperature of warmer latitudes. Obeying the law of cyclonic wind circulation the warm lower currents, which flow from the south in the east quadrants of areas of low barometric pressure, *underflow* colder upper currents from the west and northwest.

As a result of these movements of the lower and upper currents, and of the lower surface temperature in the higher latitudes, a body of warm, moisture-laden air is accumulated beneath masses of colder air. As a matter of fact the warm air flows into an atmospheric pocket, which is lined on all sides save the south with colder air, with the coldest side on top. And it is on the coldest side of the pocket that the moisture in the warm air is first condensed into rain or snow; on the other sides the differences in temperature are not so marked, and clouds only, are formed.

In winter the operation of this process is shown when snow closely follows the passage of a cold wave; and it is well to note in this connection, that the process is operative only in districts covered by the sweep of the cold wave, and that in cases where the low temperatures are carried far to the south of a district, cold, and not warm, air is drawn from the southern latitudes and a temperature gradient, sufficient to produce precipitation in the form of rain or snow, is not established. Investigation shows that many unexpected snowstorms have been produced by this apparent cause, and also discloses instances wherein snow has been expected when the conditions governing the process have not been fulfilled as regards the geographical extent of the cold wave.

During the warmer months rain does not so closely follow the shift of wind to southerly in the wake of high barometer areas; it awaits a nearer approach of the center of the succeeding low barometer area, and the colder upper currents appear to overflow the central storm area and have a more active part in the rain producing process; in other words summer rains are apparently produced by the descent of colder upper currents in the south quadants rather than by an under-

flow of warm air in the east quadrants of areas of low barometer. In apparent accord with these conclusions the precipitation of the warmer months is confined largely to districts lying south, and in winter to districts lying east of storm centers. To be more definite the heavier summer rains fall in the southeast, and the heavier winter rains or snows in the northeast quadrants of areas of low barometric pressure.

In further considering the rain and snow producing processes under discussion, it may be interesting to speculate as to the probable value of aerial observations as a means of foreseeing the establishment of vertical temperature gradients sufficiently marked to produce precipitation in the form of rain or snow. These observations have shown that the diurnal range of temperature is practically eliminated at a height not greater than about 3,000 feet, and that under average conditions there is a decrease of temperature of about 1° for each 300 feet of elevation. They have also shown that at certain times and under certain conditions this temperature gradient is inverted, and that following a winter cold wave the air is warmed much more rapidly at a moderate elevation than near the earth's surface.

The establishment of the last fact is important in connection with a consideration of the snow producing process herein referred to. As snow, which closely follows a cold wave, is preceded by the appearance and evident formation of lofty cirrus, blending into cirro-stratus, clouds, it is probable that at such times the warm lower currents have a great depth; and while this warm lower body of air extends far beyond the extreme height at which observations have been taken, and presumably has a depth of at least four or five miles, it is quite probable that observations taken at an elevation of one or two miles would, under the conditions defined, show the rapid increase of temperature which precedes cloud formation and subsequent snow before the increase is indicated by surface observations.

During the summer months observations taken at these heights would unquestionably be of great value. In that season eye observations alone show that the rain-bearing clouds, which mark the limit of the warmer lower strata, have a very low altitude. Evidence of this is found in observations of thunderstorms and local rains whose occurrence is confined almost wholly to the warmer months. These storms commonly occur in the southern, and usually in the southeast quadrant of low barometer areas, and the low and rapidly moving scud clouds which forerun their breaking, and the cumulo-stratus clouds which frequently attend them, seem at times scarcely higher than the loftier trees and buildings; and the quick downrush of cold air, which is a feature of thunderstorms, is also a proof of the comparative shallowness of the lower warm strata during the period when summer storm conditions prevail.

It would appear, therefore, that observations taken at heights available with present appliances should yield valuable material for the investigator, and data calculated to supplement present skill in the art of weather forecasting.

TOPIC No. 7.—RELATIONS WITH THE PRESS, COMMERCIAL BODIES, AND SCIENTIFIC ORGANIZATIONS. HOW PROMOTED.

E. A. Beals, Cleveland, Ohio, and A. F. Sims, Albany, N. Y.

Mr. Beals. I have long recognized the importance of the relationship existing between the Weather Bureau and the press, and I have given some thought as to how this relationship might be brought still closer to the mutual benefit of both parties. To voice my ideas into lucid and succinct statements, a rehearsal of a few well-known facts showing the motive governing the actions of both will not be out of place.

The Weather Bureau, in the first place, desires to utilize the press because of the unexcelled advantages it offers in the quick dissemination of weather reports issued for the benefit of the public, while the press, on the other hand, desires to publish these reports because they constitute news, and upon the quantity and quality of its news service depends the success of the newspaper. Thus is seen at once the strong inducement for cooperation existing between the two services. Wherever there is cooperation it is expected that benefits will accrue to a greater extent than would otherwise be the case.

The union existing between the Weather Bureau and the press, while it is not recognized as conveying a premium in dollars and cents, has underlying it the same incentive as would be the case in profit sharing; therefore, each of the services desires to use the other to advance its own interests. The publication of weather information then is excited by contrary motives, and it is to the interest of both parties, if the cooperation is to give perfect satisfaction, that they come as near together as possible in meeting each others wants. As an aid in this direction it is necessary that the situation be analyzed from both standpoints.

As I understand the newspaper side of the question, it is purely a commercial one. The success of the paper depending largely upon the quantity and exclusiveness of its news. Its employees are instructed to gather this news quickly, to obtain that which will interest the most people of all classes, and get "scoops," that is, to endeavor to get interesting news ahead of other papers. The more exciting, interesting, and exclusive it is the greater the merit and consequent reward to the agent collecting it. For this reason, newspaper men while anxious to get facts desire to arrange them so as to attract the most attention. The change of a comma in a sentence oftentimes alters its meaning very much. The emphasizing of a few words gives ideas considerably different from those intended, and an ingenious reporter, together with his colleague, the head line artist, does not find it difficult so to arrange an interview with the innocent weather man as to give him a very great start when he sees it in cold print. Thus, I have known the ordinary storm warning message containing the not very startling words, "Storm central over Manitoba, moving east; south winds will probably become high to-night and shift to west by Saturday morning; rain turning to snow Saturday," to be transposed in headlines something like this:

GREAT GUNS!
WIND WILL BLOW A GALE.
CYCLONE, BLIZZARD, AND SNOW
PREDICTED.

A notice of this character works a great injustice to the Weather Bureau, which desires its reports published without distortion or embellishment. Especially is this so in the case of ordinary weather stories given to the press from time to time. They, being of a scientific character, should be presented in a clear and unvarnished manner and devoid as far as practicable of all technicalities. The simplest language adequate to convey the desired information is far better than a complexity of scientific terms that only mystify the general public and thereby lessen the readableness of the article, in consequence of which its instructive or educative value is curtailed.

I believe that the occasions are numerous where officials fail to respond to the wants of the public, although having the material at hand for a very interesting story and the reporter right there to receive it. The reporter is rarely a scientific man, and seldom understands the workings of the Bureau sufficiently well to tell the story without your aid. You, not having the reportorial instinct for news, overlook the fact that there is anything to be made out of what you have, and thus the opportunity is lost. Our service loses, in this way, a chance to benefit or educate the public regarding some matter of note, and the newspaper has also failed to meet its wants in this respect. Both are anxious to serve, and the failure is almost, if not entirely, due to lack of a little care and judgment upon the part of the official in charge of the local weather office.

In my opinion there are a few officials in our service who go to extremes in furnishing weather items to the press. Then there are many who use excellent judgment, and take a great deal of pains in their treatment of this work. Quite a number, however, neglect it almost entirely, and when they do give out weather news bungle it most woefully.

What I wish to do is to call attention to some of these errors of omission as well as those of commission. First of all, I can not too strongly emphasize the benefits to be derived from sinking individuality, as much as possible, in weather stories. We should remember that the Weather Bureau, as a whole, demands our united efforts in its upbuilding. It is unnecessary to have our names accompany every article published; simply see that the credit for such matter is given to the Weather Bureau. My experience has been that an efficient officer's part in this connection will be duly recognized and credited, both by the public and by the Central Office.

In the baseball field team work is what counts; a club of star players without this quality will prove a losing club, while inferior players, with perfect team work, prove to be winners. The principle is the same in the Weather Bureau, and to make it of the greatest benefit individualism must be sunk.

I think the class of men who go to extremes in furnishing weather items to the press are without exception men who we may say are not highly educated; they rush into print so unwisely at times as to make the service appear ridiculous on account of the unlearned treatment they give the subject. These men, fortunately or otherwise, are generally the ones whose individualism is most prominent, and although the whole service suffers from their utterances, still it is not quite so bad as if their publications were wholly fathered by the Bureau. I can make no suggestions in the way of remedy for this evil, except, when it becomes too pronounced, to transfer such men to less responsible positions.

For the benefit of the class, before mentioned, who are neglectful, I will now try to state my idea of the way the publishing of weather news should be handled. First, we should make it a point to cultivate the esteem and friendship of the managing and city editors within our jurisdiction. This can be done by occasional friendly calls, generally made for the purpose of suggesting some improvement in the arrangement or in the character of the news regularly furnished. To make intelligent suggestions, the methods in vogue in other cities should be studied; then the wants of the community should receive consideration. These vary, of course, according as the locality is an agricultural, marine, or manufacturing center. Suggestions of this character will be cordially welcomed, and if the demands on space and expense are not too great they may be adopted.

Next, study the character of the reporters visiting your office. Make friends of them; show them that you are anxious to secure news to give them. If you can obtain anything in the news line wholly outside of your field, give it to them, or tell them where to get it. They will appreciate this interest on your part in their labors. Give them all the time you can possibly spare; they will not abuse it. I never knew of a reporter making a loafing place of a weather office. They are busy men themselves, and have other places to go when they have spare time on their hands. In your talks with reporters tell them how the service is being improved all along the line; tell them what you are doing yourself in that connection; tell them of instances occurring where weather information furnished individuals has proved of value; tell them of law cases in which the weather records have served useful purposes. Do not fail to show up all the good points that you can think of in favor of the service. I don't mean that these things should be published; when it comes to that, extreme caution must be used. These talks are to impress the reportorial mind with the importance of the work in your charge, as well as that of the whole Bureau. Not all newspaper men fully understand the scope of our work, but when one does he becomes a medium through which much good may be accomplished, whereas before he was a vehicle to be used with extreme caution.

Now, as to the news to be given out. You have a difficult task before you, for the reporter, perhaps, has only a "stickful" or two of space at his command and he wants to know "who, where, when, how, and why," regarding everything and he wants his information devoid of all technicalities. Elaborate treatises, perhaps, have been written upon a subject he expects you to fully inform him upon in a sentence or two. This, of course, can not be done, but you can always give him something interesting bearing upon the subject, and here is where your ability comes in play. Unusually hot, cold, or dry spells, heavy rainfalls, and winds all start the newspaper boys for your office. They want comparison at once, and if your records are properly kept you should be able to give them such information. If you can not, you have reflected discredit upon the service; the "oldest inhabitants" are immediately consulted to supply the deficiency, and thus the public mind receives further confirmation as to the changeableness of climate, the certainty of equinoctial gales, the infalibility of the goose bone and the ground hog in foretelling all sorts of calamities.

Another class of news to be furnished consists in seasonal occur-

rences, such as early and late frosts, first snows, when sleighing can reasonably be expected, annual floods, the opening and closing of navigation, etc. Every office should have these data tabulated, and, as the season approaches, give them out for publication. The public will be interested in knowing how this season compares with others, and the newspapers will be glad to be the medium of informing it.

Besides this class of news, there are many others constantly coming up at the various stations which can not be classified, but from which the alert weather man can, if he tries, make something that will be both interesting and instructive to the reading public.

We should ever bear in mind the powerful influence of the press for good or evil, and remember that each official is one of the cogwheels in this ponderous machine, as far as it concerns the welfare of the Weather Bureau. If we work smoothly with the rest of the machine, all is well, otherwise, not only is our lot an unenviable one but the whole service suffers in consequence.

I wish also to call attention to the fact that if a manufacturer or merchant has what he thinks is a good thing for the public, he spends thousands of dollars in advertising it. We, in the Weather Bureau, know that we have a good thing to offer, and we give it to the public without money or price. Under these circumstances, it is our duty to advertise our wares as frequently and as broadly as possible. There is no better medium by which to do this than the press, which is anxious to give us its aid as freely as we give the public our wares. Therefore, in closing, I will say that whenever these opportunities are neglected the service has failed in its duties to the public. The press, and through it, the public soon become dissatisfied and eventually the official so offending has to give way to another, without really understanding why his services received such scant recognition.

Professor Abbe. As editor I have a great deal to contend with in the way of sensational reports in the newspapers, and once or twice I have indulged in quite severe strictures on newspapers for making very sensational paragraphs out of quite ordinary meteorological phenomena. However, I do not suppose the Weather Bureau men are responsible for this. Lately, I noticed that one of our map distributors got his name in the paper as "Professor So-and-so," on the strength of having given quite an account of a case of ball lightning which was really not ball lightning at all.

Professor Moore. In regard to this subject, it occurs to me that the Weather Bureau local official, in speaking for the public, can learn a great deal from the newspaper reporter. I have spent several years of my life in a newspaper office. I was not very successful as a newspaper reporter, and therefore they made a Weather Bureau official of me. Now, I find that if you tell a newspaper man a few facts, he will gather the central idea immediately, and enlarge upon it. You, in your technical report, will often lose sight of the most essential piece of news which the weather map contains and which

would be useful to the people. In Washington, as Professor Hazen knows, we have been endeavoring to write our reports in newsy language, and put forth officially such reports as the newspaper man would write if he had the technical knowledge we possess.

Mr. J. Warren Smith. I believe that the way for an official of the Bureau to promote the best relations with commercial and scientific organizations is to be a "man among men." That is to say, go among these organizations and take his place with them and fill it in every sense of the word.

If a man can not intelligently discuss the scientific and theoretical principles relating to his own profession scientific men have no time to spend with him. If an official of the Bureau can not meet commercial bodies, which are interested in the very matters that he is supposed to cover in his work, on their own ground; if while associating with farmers he does not appreciate the details of agricultural science and practice, then these individuals have no use for him, and no faith in the benefits that he is trying to "impose" upon them.

Would Professor Moore have had the success that he did while in Milwaukee or Chicago if he had stuck to his chair as if the bottom had been made of sealing wax? No, indeed. He went out among the people. He showed them that he was an expert and not a prophet; that the Bureau which he represented was for the very purpose of benefiting them, and that he was there, first, to find out what they wanted to know, and then to turn his efforts toward the successful foretelling of those particular features. In other words, he studied his customers, which is of just as much importance as studying your goods.

The day has gone by when it was all sufficient for a Weather Bureau official to sit on a high stool beside a long desk poring over papers covered with mysterious hieroglyphics, and look wise but say nothing when a man did venture into his sanctum sanctorum. The public is being educated faster than we are if we fail to keep in touch with the world and its ideas.

The only way that a business or a professional man can keep up with the times is to be continually on the alert. And in this age of rapid progress in all the arts and sciences, as well as in agriculture, transportation, and ordinary business affairs, we become antiquated unless by persistent and intelligent effort we keep abreast of the times.

Mr. J. Warren Smith offered the following resolution:

Resolved, That the Weather Bureau officials of the Department of Agriculture, in convention assembled at Omaha, Nebr., October 13, express their official appreciation of, and personal affection for, him whose executive ability and innate kindness of heart have done so much to extend the usefulness of the Weather Bureau and to raise the standard of its personnel. We extend greetings to the Hon. James Wilson, Secretary of Agriculture.

This was unanimously adopted by a rising vote, and the secretary was directed to send a copy of the resolution by telegraph to the Secretary of Agriculture.

Mr. Sims. The duty of primary importance is the placing before bodies representing the welfare of the people as much practical information as possible.

The best method of procedure in order to make plain to the many interests of our country the valuable work of the meteorologist is the common concern of the field workers of the Weather Bureau.

In order to bring about the fruition of our hopes we must go out in the highways and byways of commerce, agriculture, and science, and exact as tribute attention to the truth acquired by the pioneer investigators and zealous students who are blazing the way across the unexplored realm. We must lead the people out of the darkness of ignorance into the light of intelligent meteorology.

Great principles can not be stated in a few hours or understood in a few weeks; therefore, we must cultivate patience and persistence, and find strength in the knowledge and belief that purity of purpose, the common heritage of us all, combined with zealous effort and readiness to profit by the teachings of experience, seldom fails of its reward.

A detailed survey of the field of effort makes plain the fact that the special need of our time is meteorology made popular and practical and widely disseminated. To meet this need we must bring ourselves to the level of the plain people and impart to them in simple language a knowledge of the elementary principles of meteorology as found in the prefatory pages of the book of nature.

Any system of instruction must start by taking in the natural endowments, and must provide for their fullest development. We must awaken the imagination before we can successfully open the mind; this is the key which will unlock the students' inner nature. The well informed official can draw aside the curtain, see what is there, and sow the seeds of weather lore to take root and bear fruitage in the world.

There are certain lines on which the early meteorological training of commercial men must necessarily follow, courses distinct from those pursued by members of the professions; yet in some other respects both classes can pursue a parallel course, the only difference being that with the professional the process is slower, both in work and tangible results. We must apply to the business community, through its various organizations, the methods that have brought about a better understanding of our work on the part of the press.

The scope of the practical application of Weather Bureau reports will increase in proportion to our efforts and success in making them easily understood by the business men. The official should survey his field, district the business section of his city, arrange to make timely visits to the merchants especially interested in and benefited by weather reports, and get them in touch with the details of Weather Bureau work. As a general rule the active merchant can not conveniently devote, during business hours, the time necessary for that intensive study of weather publications which will help him in his work. As a general rule, theory neither attracts the business mind nor arrests its attention, and increased results follow only when mem-

bers of the staffs of the various boards and exchanges meet with the Weather Bureau officials for the mutual exchange of ideas and suggestions designed to increase the practical application of weather reports. Staff officers of the boards and exchanges having the field of effort and its condition constantly before the mind's eye are thoroughly competent to answer intelligently questions regarding weather, crops, and prices.

We act in the capacity of purveyors of facts and generalizations regarding the weather in shape best suited to the various business interests. The staff officer in charge of the bureau of information can furnish members facts and figures; the application of the data is the concern of the member.

The official charged with the duty of issuing daily synopses of the weather should keep in mind the interests best served with weather reports and incorporate in his writings such timely facts as will best serve particular interests during critical periods.

To the assistants on stations located in our large cities should be delegated the work of keeping thoroughly posted on grain, cotton, etc. They should cultivate the acquaintance of the man in charge of the exchange desk of a great daily paper and secure all exchanges containing interesting items regarding the weather. They should seek to induce elevator companies and extensive grain dealers to give copies of the daily rainfall information received by them from correspondents located in the principal wheat, corn, and cotton belts. The superintendent of telegraph of the granger railroads should be requested to secure from train dispatchers along the line of their roads, at the time of test, reports of rainfall or damage by storm. Probably this could be considered as railroad business, and not in violation of the contract by which a railroad leases wires from a telegraph company for the transaction of railroad business. The principal wheat, corn, and cotton areas should be plotted on a chart by townships, together with the percentage of yield as given by the United States Department of Agriculture, the acreage on which the percentage is based, and the daily rainfall.

A synopsis of the rainfall, together with interesting information regarding the effect of weather on crops, should be printed on the back of the chart. To be plain, we should have our wheat man, our corn man, our cotton man, on each large station keep thoroughly posted on specialties from seedtime to harvest, and write his line in a popular style and publish a daily synopsis, especially during critical periods. Each popular bulletin should give the situation up to date and be progressive; the latest bulletin should contain a statement of the salient features of the preceding sheets. This system is calculated to serve as a herald of the great weekly crop bulletin now issued from the Central Office.

Many business men of to-day have not had the benefit of even the least personal study of meteorology, and I know of no better method of lifting them to a normal meteorological plane than that of giving, during the winter evenings, when "smokers" and "kommers" are in order, short talks on the practical use of weather reports, and imparting to them in a simple way the gist of the information that is contained in the chapters on meteorology printed in the standard physical geographies for the benefit of our future commercial men. As a general rule, many leave school and enter upon a business career with a

bare modicum of knowledge of the higher branches of study. For that class the chapter on meteorology has especial value.

The daily weather map is the one publication around which the structure of our Bureau is being erected. The business men of to-day require an early service, and that demand will be satisfied if the official will glean the most salient features of the daily map and present them to the business men in the form of an attractive bulletin. Pictures and drawings please the popular fancy, for the reason that they require a minimum of effort to comprehend. They are intelligible to the mind insufficiently tutored to intelligently conclude from a column of figures. A picture of the weather and temperature flags to the right of the wording of the daily forecast, the Washington forecast, in red; the cold wave, information, or other signal, to the right of the wording of the warning message received from the Central Office, in blue; the synopsis of the weather report, in black; in short, all the information that an official has at his disposal can be sent out in a simple and attractive form one hour earlier than the weather map.

The Monthly Weather Review commands respect and admiration, but it is unknown to the plain people, for the reason that it does not appeal to them in a popular form. All interests would be well subserved by maintaining the present high standard of the Review, while also adding elementary lessons tending to explain the alpha and omega of the aerial ocean. The Weather Bureau kite could be used as a vehicle for these popular trips through the atmosphere and affords a popular way to treat storms of the month.

Normal colleges are well fitted to materially aid in the mission of educating the public in meteorology, for the reason that many of their graduates enter the ranks of teachers. A little effort and tact on the part of the official will result in preparing such students, so that when they enter the ranks as teachers they will be thoroughly competent to explain in simple language the weather maps and cards posted in the class rooms.

At teachers' institutes, such as are held every year in the Empire State, the secretary can arrange to have papers on meteorology in its relation to school work read and discussed, and, with them, short talks on how to use weather reports will be productive of much good.

Many fortunate young men of our cities, towns, and hamlets are temporarily absent from the home fireside while attending college. As a general rule, they arrange to spend the vacation season at home. At that time it may be easy for the official to interest a young college man in the modus operandi of a station of observation. In one case, at least, such effort has lead to the organization of a science club at college and the acceptance of questions in meteorology as subjects for debate.

Such work is well calculated not only to interest the parent in our service, but tends to cause the student to study, not with the mere object of attaining high marks in the class room, but the further object of turning such study to practical account after he enters the business world to achieve his own fortune.

Even the kindergarten presents a field in which one can make primitive meteorology the favorite nature study. The official can cooperate with the teacher by furnishing drawings of a cloud form, a thermometer, a barometer, a wind vane, a rain gauge, etc. One child can cut while another can paste the pieces together. In this connection I

would suggest that this matter be brought to the attention of the National Educational Association, with a view to having the work herein outlined introduced in the schools of our land.

It might be of interest to you to know that our maps are eagerly scanned by the pupils in the Institution for the Instruction of the Deaf and Dumb. The supervisor of that institution was instructed in our methods, and now some of his boys are well advanced in elementary work.

Some time ago a gentleman called at the Albany office of the Weather Bureau and stated that the young men at the General Electric Works were so interested in the weather map that he was obliged to remove it from his office room to the hall. When we consider that these student engineers come from all quarters of the globe, such a report is, to say the least, most gratifying.

An interest in meteorology can be stimulated by the incorporation in the regents' examination papers of questions relative to the elements of this subject.

Secular schools offer a wide field for legitimate effort, but not the only field, as you will learn through the following incident: Not long ago it was my good fortune to casually meet the pastor of a church to whose care is confided the management of the House of Shelter. While homeward bound the conversation flitted from one subject to another, and finally rested on the topic of the weather and the forecast made by the Weather Bureau for the great floral parade held at Saratoga, N. Y. The conversation brought out the fact that the clergyman was inclined to the belief that the study of meteorology tended to make man agnostic. He also stated that it gave me employment, and thereby operated in the direction of doing good. I pleaded in bar trial to the first specification, and guilty to the second. I told my friend I was glad to learn where he stood, for the simple reason that it afforded me an opportunity to labor in a rich, uncultivated field, and sow acquired truth. I stated my belief that agnosticism was not favored by scientific pursuits, and assured him that the study of meteorology brought the creature, man, nearer the Creator. I pointed out to him a line on which Sunday school teaching could be made interesting. Observation teaches us that the comparative and inquisitive mind finds difficulty in harmonizing the doctrine of the three persons as one and the same (The Trinity); it very often proves a stumbling block unless we seek its counterpart in nature, e. g., hail, rain, snow, the three totally different in appearance, yet when subjected to heat the same—water. I stated that meteorology had lifted the veil for me, and while I could reason in the abstract, to my own satisfaction, at least, as to whence we came and whither we are drifting, I could not conceive of a beginning for the Creator himself; however, in the light of past events, and in view of the fact that meteorology had solved many perplexing problems for me, I looked forward to a future replete with bright promise. I assured him that I would not advocate the substitution of philosophy for religion, or unduly cultivate the abstract reason as the basis of the former, and ignore the superhuman as the condition of the latter. Admitting that all projects fail when they do not tend to cultivate the spiritual sense which reveals God, we should teach that moral freedom is the chief end of man, and that among other methods meteorology can also be used as a means to that end. My friend in

parting urged me to think of more illustrations for him. This comes under the head of special privilege, for the reason that it is the best method of promoting the interests of meteorology, and tends to converge all paths to the brotherhood of man and the Fatherhood of God.

When requests for maps are received from teachers and others interested in our work it would be well to state in reply that the Weather Bureau extends the courtesies of the office, and that the official in charge would be pleased to have the teacher, scholars, and others call when they next visit the city, and learn the modus operandi of a station of observation. Such an invitation will invariably be looked upon as special; it will be far more effective than the general invitation printed in our publications.

We should seek opportunities and get in touch with agricultural associations for the purpose of devising ways and means for obtaining and furnishing the data best suited to show the importance of local climate upon plant life. We help to place the American farmer above competition by enabling him to make the most of his acres through the selection of plants best adapted to his soil and climate.

In all cities the problem of the water supply is becoming more perplexing. We should consult the engineering association and other scientific organizations, learn of their needs in our line, and set about to furnish the data.

The medical associations and sanitary architects of to-day are not at all decided as to the lines on which our work, so far as relates to them, should be laid down. We must take the initiative. To the casual observer it appears likely that in the study of atmospheric pressure during the season when the ground is frozen may be found the true solution of a problem involving sanitary architecture.

As is well known there is an afflicted element in our population who are always seeking to restore health, prolong life, or ward off threatened disease. For them and the guardians of the public health a publication, giving a classification of climates best adapted to combat diseases in their various stages, would be valuable and would fill a public want. The publication should give the location of all sanitariums, the elevations, and local climatology, also the routes by States and seasons over which patients can best travel. With such a publication at hand the physician could map out a trip with a view solely to the patients welfare, and not leave the matter to a ticket agent who is trammeled by the consideration of commissions, etc. In every community one can find some old mechanic whose associates and surroundings are of a thoroughly bohemian character. The arguments, and all incident thereto, given and taken over the work bench possess a value and often prove far reaching in their results; such men may be found to be competent to discuss subjects in elementary meteorology and devise apparatus and mechanisms.

One could go on *ad infinitum* pointing out where it is possible to open up new lines of activity. Experience teaches that as to meteorology it is much easier to instruct the young than to convince the old. We need to labor all the more diligently with those who have attained maturity, for it is among the older members of a community that we find a proneness to criticise unjustly and unfavorably that which they do not understand. Our efforts to spread the truth will lift us above our own intellectual horizons and give us glimpses of the light beyond.

In conclusion, it may be stated that absolutely correct weather forecasts would bring about universal peace of mind, prosperity, happiness, and all that is truly good. How to gain a comprehensive knowledge of the surgings, tossings, and pulsations of the aerial ocean has occupied my leisure moments ever since I began to study the serious side of our work, and while I have perceived many objections, surmounted many obstacles, and eliminated many faults in my plan designed to better our instrumental equipment, I am loath to explain it now, for the reason that, while I firmly believe it will prove to be practical, I am not thoroughly satisfied with it, and to a casual observer it will appear frivolous and only worthy of a place among iridescent dreams. However, be that as it may, the mechanism I have in mind is intended to make a continuous record on a movable board, so that an official can step into the instrument room at any moment and get a kaleidoscopic view of the bends and changes in the isobaric and isothermal lines and their history for the day.* The Central Office register or map maker is to have a number of coils, two for each reporting station, each pair of which acts as automatic cut-outs and completes the circuit through the up or down pen of its own station, and thereby induce in the Central Office arm the motion of the corresponding station arm. The synchronizing circuit of the central Washington clock is to be used for this automatic work. The system herein outlined could be best perfected by experimental work in the Central Office laboratory where a number of barographs and thermographs could be subjected to variable pressure and temperature and cut in on an improvised circuit. The considerations entering into the question of the adoption of the plan outlined are cost and value. It may be stated that this method provides for a minimum of telegraph service—the man on guard would send out warnings of no uncertain value, and only in the direction in which warnings are needed. The data secured would in all probability advance the standard of meteorology far beyond the hopes of the mortal of to-day. It would revolutionize and simplify our service, and bring to the perception of finite man that which is now infinitely beyond his ken.

In this connection I respectfully suggest that a sketch plan and specifications of the proposed system be made and submitted to our station men for study, suggestion, and remark. Make it, as it were, a contribution to meteorology from America. After all the testimony is in, the Central Office staff can classify all suggestions and remarks of apparent value and evolve the best mechanism to bring about the fruition of our hopes.

Professor Abbe. I have always been curious to know how many of our men have actually done something toward getting meteorology taught in schools. How many of you have had a chance to talk to schools, or colleges, or universities, or to teachers, in any way? Please rise.

(Nearly everybody present rose.)

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* A spider web with its occupant crossing the radial lines does not look unlike the chart the mechanism would make. Meridians and parallels stand for lines in web, and storm areas crossing plots take place of spider.—A. F. S.

Mr. T. B. Jennings. I would like to go a little further. The school is not the only place where you can teach. I find the Epworth League, and organizations of that kind, very anxious to receive this information. At Topeka we have a number of organizations of that character, and they give me very frequent calls. I have to make regular visits to the city schools and the schools near the town, but in addition to that there are Epworth League and other organizations of a literary nature in the town. You can create an interest in the subject of meteorology by bringing it to the attention of these meetings.

TOPIC No. 8.—METEOROLOGICAL STATISTICS: HOW TO IMPROVE THEM THAT THEY MAY MEET THE NEEDS OF THE MEDICAL PROFESSION, HYDRAULIC AND SANITARY ENGINEERS, PROMOTERS OF IRRIGATION PROJECTS, ETC., AND DOES THE PRESENT MONTHLY SECTION REPORT MEET SUCH NEEDS?

E. W. McGann, New Brunswick, N. J., and W. M. Wilson, Milwaukee, Wis.

Mr. McGann. Owing to the very limited time at my disposal, I find it impossible for me to enter into a lengthy discussion of the subject, "Meteorological statistics: How to improve them that they may meet the needs of the medical profession, hydraulic and sanitary engineers, promoters of irrigation projects, etc." In New Jersey the meteorological data already collected, tabulated, and published from time to time, have been of incalculable value to the several professions named.

As far back as 1886, the late Prof. George H. Cook, Director of the New Jersey Weather Service, said that the objects of the service would be to observe and utilize every feature of the weather that affects the prosperity of the citizens of our State as to crops, health, life, etc.; that it would give to every county a government standard of temperature and rainfall; that it would put within the reach of local agricultural societies means of accurate observation which in course of time must be valuable to any locality in the study and adaptation of cereals; that it would lead to the collection of rainfall data over the different watersheds of the State of New Jersey which supply the waterworks of our large cities; that it would call attention to our winter and summer resorts as to their desirability as residences and to a better practice of medicine, when the physicians throughout the State could study disease with reliable and accurate data by their side; that it would give valuable aid to engineers, in the study of the rise and flow of the various streams, and also furnish invaluable information in the study of irrigation. Now to prove that we have done all this, I respectfully refer you to the subjoined letters from celebrated engineers and professors of our State experiment station, as to the practical value of the work already performed by the New Jersey section:

New Jersey Agricultural College Experiment Station,
New Brunswick, N. J., October 5, 1898.

Dear Mr. McGann: Concerning the weather reports and crop bulletins issued from your office, I find both of them, in different ways, to be of great importance to me. The development of insects is influenced to a very large extent by the weather, and sometimes by the weather during a very brief period.

This has been known in a general way for a long time; but heretofore we had only a vague conviction that a season was wet or dry. Since I have had your reports for constant and ready reference I have been able to certainly connect the unusual abundance of certain species with certain weather phenomena. Thus, I have been able to warn melon growers in our State that whenever there was constant warm, pleasant weather, with moderate rainfall, between June 15 and July 10, they might expect serious injury from the melon-plant louse; but whenever, between those dates, there occurs a heavy or cold storm, little or no injury is to be anticipated. This one fact, definitely established, is of great money value to our vine truck growers, since it enables them to either prepare for fighting the insects or for substitute crops, in case they prefer not to do so.

Other cases might be cited of equal importance, but this is enough as an instance of why I consider the reports of such great service to me.

The crop bulletin, with the service so well established throughout the State, gives a weekly picture of the conditions as they appear to the farmer, and enables me in many cases to note the appearance of an unusual or threatening pest, while in all cases I have at the end of the season an account of all the notable insect occurrences of the season.

The service, from this one standpoint alone, is abundantly worth all that it costs.

Very truly yours, JOHN B. SMITH.

NEW YORK, *October* 4, 1898.

Mr. E. W. MCGANN,

Director, New Jersey Weather Bureau, New Brunswick, N. J.:

DEAR SIR: During the period from 1890 to 1894 I was engaged in investigating the capacity of the streams of New Jersey to furnish water for public water supply or for water power. In connection with that investigation I gauged a number of streams in the State, and obtained from you contemporaneous rainfall measurements upon the several watersheds. The purpose of my investigation was largely to determine the relation between the run-off and the rainfall, and to trace the storage of rainfall in the subsoil and its later delivery to the stream during periods of light rainfall. In connection with this work your rainfall statistics were of the greatest value. If you had not been in position to furnish them, the expense of my investigations would have been greatly increased, and to such an extent that their practicability would have been threatened. In connection with this and other investigations, I have used your records continuously since the inception of your work, and they have proved to be of great value.

My practice in New England and the Middle States being mainly in the line of water supply and water power has made me so dependent upon the work of our Weather Bureau that I can scarcely conceive of the possibility of going back to the conditions of some years ago. It yearly becomes necessary to estimate more accurately the amount of precipitation, evaporation, percolation, and run-off of our several stream basins. Indeed there are many questions still to be solved in this connection, and the results of such a thorough study of the subject as is made possible by such full records as you have kept in New Jersey will undoubtedly add largely to our knowledge of the laws and conditions which affect the yield of streams, the height of the water table in the ground, the amount of evaporation, etc. These problems are important to the hydraulic engineer, the sanitarian, and the scientific farmer or horticulturist. It is especially advantageous to have the stations close together, as you have them in New Jersey, where they are so distributed as to properly represent the different types of topography and varying exposures to the storm winds.

I have long been of the opinion that the best way to determine the relative amount of evaporation from forested, cultivated, or barren country is to carefully measure the rainfall for such areas and at the same time the amount of water running off in the streams. Such observations over a number of well-selected watersheds must give more accurate information than any experiments on a more limited scale. The planning of the important and costly works needed to supply water to our cities, to dispose of their sewage, to produce water power for electric transmission, etc., requires accurate knowledge as to the yielding capacity of our streams, the ultimate source of which is, of course, the rainfall. Furthermore, I have long been of the opinion that there is a fairly well-defined connection between the prevalence of certain diseases and the rise and fall of the water in the ground. I will note in this connection, however, that the rise and fall

of this ground water is not always, as has sometimes been supposed, exactly contemporaneous with the occurrence of heavy or light rainfall.

But the engineer or sanitarian is also concerned with the temperature, which increases or decreases the amount of evaporation. He is likewise interested in the wind movement and position of the barometer. In fact, he needs daily the fullest possible record of the weather conditions in his district. I can not fully express my appreciation of the value to me of such records as you are making in New Jersey.

Yours truly, C. C. VERMEULE.

Prof. B. D. Halsted of the New Jersey State Experiment Station, New Brunswick, states as follows:

The meteorological data compiled by the Weather Service are of great value to me in my work in many ways.

1st. By means of the weekly crop bulletin I am informed of the condition of the various crops as concerns their fungous diseases.

2d. The bulletin gives an opportunity for informing the crop growers upon the nature of certain outbreaks of rust or blight, with remedies for the same.

3d. The monthly record of the weather is of special importance to me in my work with plant diseases.

4th. The annual reports are most of all important, as a record of meteorological facts from which generalization may be drawn of great value to crop growers.

The following statement is by Director E. B. Voorhees, of the New Jersey State Experiment Station:

The New Jersey Experiment Station has for the past four years been making a study of the need of irrigation in the State, and in this work the records of the Weather Service, both in reference to the rainfall and temperatures, have been of inestimable service. From these data we are able, not only to determine the deficiency in rainfall from the standpoint of actual supply of water to plants from that source, but also the influence upon the flow of streams from which irrigation waters may be derived. Thus, a careful study of this matter has indicated, not only the direct need of additional water, but the areas that are capable of being brought under water by means of ditches and canals. It has been shown that even in the driest year which has been experienced, and in which the need of water is very great, the supply from streams is sufficient to irrigate 325,000 acres, which, if properly managed, and at a reasonable cost, would increase the value of the agricultural products at least 30 per cent. As before stated, the data upon which this conclusion is based could not have been derived without the careful records of rainfall and temperature.

Mr. WILSON. By arrangement between my colleague and myself, it has been agreed that my remarks should be confined principally to climatic statistics as applied to what may be termed medical meteorology. There can be no question as to the intimate relation existing between climatic conditions and the production and the cure of disease, and the truth of this statement has been most forcefully illustrated by the experience of our troops in the recent Cuban and Puerto Rican campaigns.

The origin of diseases which are produced or propagated by certain conditions of temperature, moisture, and wind can be studied only in the light of a complete and comprehensive knowledge of the meteorological conditions which go to make up the climate where such diseases are found, and manifestly it is one of the important duties of the Weather Bureau to furnish this information in proper statistical form for such investigations.

Two questions immediately present themselves: 1st. What particular meteorological statistics are needed by the medical profession in order to enter upon an investigation of the origin and prevention of those diseases known to be largely dependent upon the influence of

climate? 2d. Does the present form of statistical information meet the requirements in this connection? It is a well-established fact that the propagation of the germs of disease, so far as the natural conditions of climate are concerned, depends mainly upon the proper degree of temperature and a sufficiency of moisture, but the exact degree of temperature which is most favorable for their development and growth or that under which their destruction is most readily accomplished must be determined for each special group by experimental investigation. To illustrate: The germs of yellow fever are destroyed or, at least, rendered latent by a freezing temperature, while those of typhoid fever and smallpox resist almost any ordinary degree of heat or cold. It has been only of comparatively recent date that the so-called "germ theory" has taken firm hold upon the medical profession, and there are still many eminent physicians who are sceptical as to the truth or value of the theory, and argue, with much show of reason, that climatic conditions have more to do with decreasing the power of the human organism to resist disease than in vitalizing the germs to the point of aggressive activity. The truth probably lies between the two extremes, but the difficulties to be encountered in an investigation of this character render a speedy solution of the problem extremely improbable. In either case, however, climatology is the important factor, and it can scarcely be said to be the province of the Bureau to settle the biological question.

During recent years there has been some work attempted and something accomplished in the field of medical meteorology, but what has been done can scarcely be called even a beginning. The ground has not yet been marked out, nor the lines upon which the investigation should proceed established. The work thus far accomplished has been often done by those not actively engaged in the practice of the profession, and ofttimes with but little support or encouragement. Indeed the average practitioner has little time and scarcely any opportunity for original research, especially on a line requiring a specialized knowledge of both medicine and meteorology.

His energies are directed to subjects, which if less difficult, are to his mind more practical, and give greater promise of immediate returns, and for future progress in this direction we must still look to those who are without the active ranks of the profession.

In regard to the form in which meteorological statistics should be prepared for the use of the medical profession, it would seem that there is greater need of an active effort to increase the interest of the rank and file of the profession in the work already done, and to secure their cooperation for the future, than of any elaborate change in the present methods of publication of our climatological statistics.

With the lengthening of the term of study to four years, which has been adopted by most medical colleges, it would seem that short courses in the elements of meteorology, with special attention to sanitary climatology and engineering could profitably be introduced into the curriculum of every medical school. This would at least give the practitioner a working knowledge of meteorology in its relations to medicine and sanitation, and render the work along these lines more certain of appreciation. Until this elementary work is accomplished, any effort in the direction of medical meteorology will be largely devoid of practical results. From my observation and experience I am confident that meteorology is fully abreast of

medicine so far as each science relates to the other, and I am constrained to the opinion that under present conditions any radical change in the form of the statistical information compiled by this Bureau could not be profitably introduced.

Professor HAZEN. I was much interested in Mr. Wilson's remarks as to the proper form of meteorological statistics for the benefit of physicians. Whenever there has been a medical congress in Washington I have taken pains to ask just exactly what physicians want in the line of statistics. They are not agreed. Some want the relative humidity, others the temperature; and as near as I can make out, aside from those referred to by Mr. Wilson in regard to the effect of heat and moisture upon germs in such a climate as Cuba, physicians are not agreed as to what they want. We may well wait until they are agreed. I think Dr. Baker, of Lansing, Mich., is the only physician who has devoted special attention to this subject of medical climatology; and all his work, I think, is in regard to seasonal effects. At present, therefore, the medical world is certainly at a loss in regard to what it wishes from the meteorological standpoint.

Mr. CLINE. There are a great many physicians who have never studied meteorological statistics, and many of them know nothing about handling meteorological instruments, because when they were studying medicine, meteorology was not taught, and in a great many schools it is not taught to-day. Before we can get any class of men to agree as to what they want in any line of statistics, we must first instruct them as to how we get those statistics. Now, in Texas I don't believe they teach meteorology in any practical way in the university, but in the medical department they have a graduate course of lectures which is given to the third and fourth year men. This course of lectures is required of every candidate for graduation; they must pass an examination in it, and it counts for 20 per cent in pathology. I think it would be a good idea to get the universities to add a course of meteorology, theoretical and practical, to the curriculum of their medical schools.

Professor HAZEN. Taking the question of consumption, for example, you will find almost every physician says you must have a dry climate for that disease. Yet physicians say Madeira is one of the best places for consumptives, though Madeira has one of the dampest climates.

Professor ABBE. This topic may justify me in saying one word about the subjective temperature. We can individually make a small contribution to this subject. I think the simplest way is this: When you think "This is a lovely day," make a note of it. It may exhilarate you, or it may quiet you, but anyhow make a note of the fact

that with this wind, this temperature, and with this moisture, you feel first rate. Keep this little record for a year, and when you get through you will see what a great variety of atmospheric conditions you have experienced and yet felt magnificently every time. Do not let this seem like a *reductio ad absurdum*, but send these data to me and I will put them in a little chart that will illustrate the subject very instructively. The horizontal line will be for relative humidity, the vertical line for temperature. The figures for wind velocity will be written at the proper point to indicate that one feels first-rate at that temperature, humidity, and wind. Eventually we draw a line of perfect comfort; and this line differs wonderfully through the year, as we adapt ourselves to the seasons.

TOPIC No. 9.—PAPER: SOME NOTES ON AGRICULTURAL METEOROLOGY, WITH SPECIAL REFERENCE TO THE RAINFALL ELEMENT.

CHARLES E. LINNEY, Chicago, Ill.

Mr. LINNEY. The great fund of climatological information and the weekly and monthly bulletins of the Weather Bureau serve not only to show the effect of untoward weather conditions upon growing crops and the conditions under which they thrive or perish, but also represent the agricultural possibilities of each State, and the many other problems of interest and value connected with the general science of meteorology and climatology within the United States. The field covered is large indeed, and one can not hope to do more in a limited paper than to touch lightly upon a small portion of it. I wish, however, to delve into a few of the more common things in agricultural meteorology, with special reference to the rainfall element.

The rainfall element may properly be considered as first in agricultural meteorology, since upon the moisture, next to the temperature if not in advance of it, a country becomes fertile or barren. It is true that moisture can be artificially supplied if bountiful Nature fail, but even to attain this end knowledge should be had of the desired amount of moisture and the time when it should be supplied, not to mention also, the soil, the crop, the season, and other conditions that combine to make a country either fertile and bountiful or barren and sterile.

It is said (Year Book, 1894, p. 156) that in the humid portions of the United States, having a mean annual rainfall of about 40 inches, 50 per cent flows off into the streams, and is of no direct benefit to agriculture. This excess of rainfall reaches the streams partly by flowing over the surface of the ground and partly by slow percolation through the soil, and thus only 50 per cent of the rainfall, or 20 inches annually, evaporates directly from the surface of the soil or is transpired by plants. Therefore, there are about 20 inches of rainfall at the disposal of the agriculturist, and the highest art of cultivation consists in conserving this moisture, reducing that lost by evaporation from the surface of the soil to a minimum, and maintaining a sufficient amount at all times for the use of crops. The figures given by Mr.

Frank Leverett, in his pamphlet on the Water Resources of Illinois, (p. 40), cause him to conclude that in this State the annual run-off is only about 21 per cent of the rainfall. The rainfall being about 38 inches, the estimated run-off is about 8 inches.

Mr. F. H. Newell, in the Fourteenth Annual Report, United States Geological Survey (Part II, pp. 95–155), estimates that the mean discharge of rivers of small size in the eastern part of the United States is about two to three times that of Mr. Leverett's estimate for Illinois. This is due to the fact that in the eastern district the discharge is accelerated greatly by the steeper slopes, and also by the greater annual rainfall, which accounts for the greater percentage of run-off.

Mr. Newell, in a diagram representing the relation of the run-off to rainfall, has indicated that for an open country, with low slopes, where the annual rainfall is 40 inches, a run-off of 15 inches may be expected, while with a rainfall of 30 inches a run-off of about 8 inches is likely to occur, and where the rainfall is 20 inches only about 3 inches reaches the streams, the quantity rapidly decreasing with less rainfall.

It will thus be seen that the current variations in the estimates of the run-off can be nearly equalized when one takes into consideration the slopes, the soil, the annual rainfall, etc., and that finally if the rainfall is about 20 inches annually, most of it will be needed to produce a crop.

The rainfall normals given in the report of the Chief of the Weather Bureau (1891–92, p. 444–445) show that for the season from March 1 to October 1 about 15 inches of rainfall may be expected at Bismarck, N. Dak.; 16 inches at North Platte, Nebr.; 17 inches at Dodge, Kans.; 19 inches at Port Huron, Mich.; 20 inches at Green Bay, Wis.; 21 inches at St. Paul, Minn.; 23 inches at Chicago, Ill., and Pittsburg, Pa.; 24 inches at Columbus, Ohio, and St. Louis, Mo.; 25 inches at Des Moines, Iowa, and Cairo, Ill.; 27 inches at Indianapolis, Ind., Kansas City, Mo., and Fort Smith, Ark.; and 30 inches at Nashville, Tenn., with slight increase toward the east and south, and marked decrease as we go west and north.

While our rainfall records are of great value, they give little more than the past conditions and the average conditions. Even the record of daily rainfall is more or less unsatisfactory, as it can never take into consideration the rate of fall or the condition of the soil at the time, or the locality of the rainfall. In regard to these points it is said (Year Book, 1894, p. 156):

> There is one factor which has a very important bearing upon the conditions in the humid as compared with those in the arid region. In the humid region of the Eastern States the soil is continuously moist from the surface down to a depth at which it is completely saturated, and from which water is constantly flowing out into wells, streams, and rivers. The water descends through the soil both by virtue of its own weight and by capillary force. According to capillary laws the water is pulled downward when the subsoil contains less water than the soil. Gravity and capillary force are both more effective in moving water through a moist subsoil than a dry one; hence there is danger in the East of water being pulled down below the reach of plants in time of drought, while in the West, where the subsoil at a depth of a few feet is continuously dry, this could not happen.

An inch of rainfall coming gently on a soil in fit condition to absorb it may prove of greater value to a growing crop than several

inches coming in a downpour on a saturated soil; the one, in fact, may be the life of the crop, the other its death by drowning, for drowning is quite as ruinous to a crop as drought. A crop season may be a highly successful one on a minimum amount of rainfall if this comes at the proper intervals and in proper amounts; it is usually a deficient rainfall rather than excess, which is the ruination of crops year after year; the deficiency generally prevails over limited areas, but often over such a large area of country that the prosperity of the agricultural community is seriously impaired, and many an individual farmer is ruined.

Practical farmers have repeatedly said that excess either of moisture or dryness is fatal to good crop growth, and yet so general a statement means little, for this general average, which is so desirable, can only be determined by the slow process of daily, monthly, and yearly observations covering a considerable period of time, and once it has been determined there is no certainty that the farmer may expect it, or that the seasons will not run by extremes.

How indefinite and uncertain this "average" condition is has been in part discussed in my first view of what is absolutely necessary to produce a crop, but it can be more clearly shown by a consideration of the amount of moisture which will produce a maximum crop, or impart to a plant its most vigorous growth and sustain it throughout the crop season. Prof. F. H. King, Director of the Experiment Station of the University of Wisconsin, has carried on an elaborate series of irrigation experiments to elucidate the question, "How important is soil moisture, and how much do our soils require for maximum productiveness?" In his annual report for 1896, p. 189, he gives the results of his experiments for that year, and compares and contrasts them with those of 1894 and 1895, the two preceding years of drought.

From his experiments it appears that during the season of 1896 not only was the rainfall fair in amount, but it was generally well distributed, and that being true, the irrigation experiments afforded an excellent means for determining, under field conditions, how much moisture is really needed in the soil to insure maximum yields.

In one table Professor King gives the seasonal rainfall from the 1st of May to the 31st of August for the three seasons. This period is three months shorter than that I have considered in quoting rainfall heretofore. But from his table it appears that not only was the total rainfall for 1896 much larger than that of the other two years, but there were only two 10-day periods when the precipitation did not exceed half an inch and but one where it did not exceed 0.3 of an inch. On the other hand, during 1894 there were six 10-day periods and in 1895 seven of less than half an inch of rainfall, and four periods in 1894 and six in 1895 when the rainfall was less than 0.3 of an inch.

During these three years corn was grown on the same piece of ground, and the mean yields of dry matter per acre may properly be used as an index of the influence which the varying amounts and distribution of rain had upon the crop yields. The total rainfall and the yields were as follows:

In 1894 a rainfall of 9.72 inches gave 6,674 pounds.
In 1895 a rainfall of 5.82 inches gave 2,768 pounds.
In 1896 a rainfall of 15.20 inches gave 7,995 pounds.

In the soil problems for 1896 clover, rape, corn, potatoes, cabbage, mangel-wurzels, and turnips were experimented on, and all except the clover were grown on soils in alternating strips of irrigated and non-irrigated land. The results with the potatoes show that, although slightly more than 15 inches of rain fell during the crop season, still five timely applications of water, amounting to 10 inches, increased the yield nearly 100 bushels per acre. With the corn, in all cases where it was possible to obtain checks, the irrigated land produced about a ton per acre more water-free dry matter than the land not irrigated; and the same general result was had with the cabbage. The cost of the irrigation was more than paid for by the increased crop yield. From which Professor King summarized the results as follows:

> The great lesson to be learned from these results is that we must have an abundance of water in order that our crops may avail themselves of the plant food stored in our soils; not that water is everything, but the fertility of the soil counts for naught without it.

These results of Professor King also show that the greatest yields were had when the rainfall and irrigation equaled about 27 inches, although the greatest gain was had when the small rainfall of 1895 was brought up to more than 31 inches by the addition of 26 inches of water, resulting in a gain of more than 200 per cent in crop yield. It would thus appear that maximum yields are to be secured with 25 to 30 inches of rainfall properly distributed during the crop season, and that with this amount of water, sunshine and temperature also being favorable, the plant has as much moisture as it requires to give its fullest energy and largest crop yield, while if more be added puddling of the soil, baking, stunted growth or drowning would result.

Where irrigation is not possible subsoiling is a very desirable feature. The effect of subsoiling upon the ground is to increase the water capacity of the soil stirred; decrease the capillary conducting capacity of the soil stirred; increase the percolation, or gravity capacity of the soil stirred for water; increase the percentage of water retained in the subsoiled ground which is available for crops; increase the chance for root development of the plant at a lower level in the subsoiled land, by admitting air and moisture; and, finally, to make available a very much larger field for plant food.

Careful observation and analysis of the waters of the sea show that the plant food lost in cultivation of the soil by leaching is exceedingly small. The sea secures mostly those alkaloids which are not needful to plant growth. The rock ingredients which are leached out in the largest amounts are those of which the smallest quantities only are required by most plants, while, of those ingredients which are specially needful to plant nutrition, only potash is removed in appreciable amounts by the weathering of the soils from excessive rainfall. On the other hand, insufficient rainfall is almost always shown by the appearance upon the surface of the land of an efflorescence of alkali salts, which characterizes the well known alkali land. And yet these arid or semiarid lands are largely composed of disintegrated limestone, or are lime lands, and are wonderfully rich and fertile, and need only irrigation and the conserving of their rainfall to make them exceptionally productive.

These facts all point to a number of conclusions. First, few of the central valleys north of the Ohio River can regularly be depended

upon to furnish sufficient rainfall during the crop season to produce maximum crop yields; they may, occasionally, but usually the rainfall will be such that the yield is reduced far below the maximum. Second, irrigation can be profitably employed in all our central valleys, and especially over the western plains, while in the more moist central valleys the largely increased yields will repay the cost of irrigation and give good interest upon the investment. Third, though the natural rainfall is much less than is required to insure maximum yields, still subsoiling and careful cultivation of the land will very materially aid in conserving this moisture and thereby greatly increase the present crop yields. Fourth, to again quote Professor King:

> The evidence stands out clear and strong in favor of plenty of water in our soils all of the time a crop is making; for, it will be seen, we are comparing our irrigated yields with good large crops produced by the normal methods in humid climates in a season of good rainfall. And we must have an abundance of water in order that our crops may avail themselves of the plant food stored in our soils.

TOPIC No. 10.—EFFECT OF FOREST CLEARING AND CULTIVATION UPON, FIRST, WATER SUPPLY AND SOIL; SECOND, RAINFALL; THIRD, TEMPERATURE.

W. M. Fulton, Knoxville, Tenn., and Geo. N. Salisbury, Seattle, Wash.

Mr. Fulton. Popular views concerning the relation of forests to soil and climatic conditions were promulgated with the earliest history of climatology, but the scientific consideration of this important question scarcely antedates the middle of the present century. Realizing, as every thoughtful mind does, that it is only through strictly scientific methods that correct conclusions can be reached, we must concede the fact that our knowledge of this subject is still in its infancy. Like all other newly evolved sciences, the crop of incontrovertible facts is still scant, and further research will be necessary in order to solve the many complicated problems which present themselves.

Systematic observation and study along this line, based upon scientific principles, have been taken up by the leading countries of Europe and also in India, and the results which are being attained would form an interesting theme for discussion. But the limited time at our disposal here precludes the attempt at anything more than a brief review of the general and well established facts concerning the effects of forest clearing and cultivation upon water supply and soil and upon rainfall and temperature. Having thus merely introduced the subject I will leave it to my colleague, Mr. Salisbury, to present to us some of the more interesting details. For the sake of convenience we will consider the subject before us under three main divisions:

1st. The effect of forest clearing and cultivation upon water supply and soil.

2d. Upon rainfall.

3d. Upon temperature.

Before entering upon a discussion of these relations, however, I wish to emphasize two important physical laws in which are to be

found the explanation for much of what follows. These laws are: first, any obstructions upon the surface soil, whether natural or artificial, which prevent the rain water from flowing away as it falls, will increase filtration and underground drainage, and hence prevent washing of the soil. The second law is: The air being a very poor absorber of direct insolation has its temperature controlled by the temperature of the surface upon which it lies.

With these two important laws in mind, let us turn our attention to the consideration of the first division of our subject, viz, the effect of forest clearing and cultivation upon water supply and soil.

In order to get a thoroughly practical view of this matter, for all scientific discussion should be practical, let us suppose that we have here before us one of our American farms. In this farm are 2,000 acres of land, of which 1,000 are cleared and under cultivation, and the other 1,000 are forest land. This farm lies in such a way that the forest and field each forms a separate watershed to itself. Now, suppose that within a certain period of time, say twenty-four hours, one inch of rain falls uniformly over this farm, on forest and field alike. What will be the effects produced upon the forest as compared to those produced upon the field?

A portion of the rain drops which fall upon the forest will be intercepted by the foliage of the trees and the water thus collected will run down the twigs to the branches and thence down the trunk of the tree to the ground. The drops which penetrate through the foliage will strike the dead leaves and fallen branches upon the forest floor and their force will thus be broken without packing the soil. The surface soil of the forest having been rendered mellow by the roots of the trees which penetrate it here and there is also covered with a thick humus of decaying vegetable matter which holds the water on the surface, thereby insuring filtration and underground drainage, while the shade of the forest retards evaporation. The rain, therefore, which falls upon the forest will be fed to the nearest water course by the slow process of underground drainage, and the water course which thus receives its supply from the forest will maintain a comparatively even flow, and will not be subject to sudden and violent overflows, except in extreme cases.

In the case of the open field, the first rain drops which fall will pack the soil, thereby retarding percolation and filtration, and the excess of water thus collected will rush down the slopes, carrying more or less of the soil with it. Upon reaching the water course it will soon fill it to overflowing. The soil, too, which has been carried down by the water will sink to the bottom and thus aid in filling the stream. Soon after the rain has ceased to fall the water supply will become exhausted and the flow of the water course will be reduced to the opposite extreme.

Hence, it is plainly evident that the tendency of forest clearing and cultivation is to produce extreme fluctuations of water supply and to exhaust the soil by washing. Practical illustrations of this are to be found almost everywhere. Along the banks of the Ohio River and in many portions of the South hundreds of fields which were once covered with sturdy forests, and which under cultivation after being cleared, bore abundant harvests may now be seen furrowed with gullies as with the wrinkles of age, and abandoned to brush and briars. In France, the government and farmers together have, of

late years, spent over $40,000,000 on reforestation and other methods for reclaiming washed soils. Some writers have supposed, and correctly too no doubt, that if the entire watershed of our great central valleys was cleared of its forests and placed under cultivation, the farmers along the lower Ohio, Mississippi, and Arkansas rivers would be visited by overflows of almost incalculable violence, and these would be followed in turn by unprecedented drought.

The next division of our subject, the effect of forest clearing and cultivation upon rainfall, is a matter to which we can only give a passing glance. Some writers hold that the forest has an attraction for the rainfall, and hence more rain will fall in the vicinity of forests than in extended open field. While certain observations seem to indicate that this is true, it still remains a question of serious doubt; even should it be found that rain falls more frequently and in greater quantities over forests than in the field, it seems highly probable that the difference is so small in amount that its effects are inappreciable.

Lastly, as to the effect upon temperature. The crown tops of the trees act in a manner very similar to that of any elevated surface. The absorption of direct insolation by the forest soil is largely restricted during the day, and radiation is similarly restricted during the night. The stratum of air between the forest floor and the crown tops is thus maintained at a more even temperature than that of the air in the open field. In this respect the effect of a forest upon an adjoining field strongly resembles that which would be produced by a neighboring body of water, except, of course, it is not so marked. This moderating effect is generally greater in summer than in winter, and is largely dependent upon the character of the forest and of the soil upon which it stands. The effect of the crown tops upon temperature does not appreciably depend upon the elevation above sea level. Much might be said here concerning soil temperatures and temperatures in or above the crown tops, and many other interesting details might be discussed, but limited time forbids further remark on this subject and I must hasten to a close.

Attention has already been called to the urgent need for more extended observation along these important lines. Nowhere, perhaps, among the more enlightened nations of the earth is this need more keenly felt than in our own country. The climatologists of France, of Germany, of Austria, and of India, may establish general facts, but they can not tell our legislators when and where to check the inroads of America's mighty and progressive civilization upon her primeval forests, nor can they tell the American farmer just how and where he shall clear his land for cultivation. These are questions which depend almost entirely upon local peculiarities, both of soil and climate, and the problem must be solved for each locality to itself. I believe I stand to-day before the ablest body of climatologists ever assembled in this country, and it is to you, gentlemen, that your fellow countrymen are now looking for the solution of these vexed problems. We are to account to coming generations for the progress made in this age along this line. Let us then, each and all, be up and doing.

Mr. Salisbury. The effect of forest clearing and cultivation on climate is a question which has occupied not only students of meteorology, general scientists, and experts on forestry, but many

other thoughtful persons who have paid no special attention to meteorological problems. No satisfactory conclusion has ever been reached. Much of the subject is still debatable ground, and it will not be expected that I shall announce any new discoveries, or throw any light on the subject here. My purpose is simply to bring the matter to general attention, as one of absorbing interest if investigations are pursued, and one worthy of the profoundest thought.

The "forest primeval" encountered by the sturdy pioneers of this country is no longer of unbroken extent. It is rather a thing "of shreds and patches," admitting that some of the "patches" are good-sized ones. The settler's axe, in part, but more largely forest fires and the swiftly moving saws of the lumbermen, have cleared enormous tracts where lordly branches once waved, or the winds sighed and moaned through the pines. Sharp, glistening plowshares have coursed through the soil, turning the moist earth to the sky and sun; ditches have been dug, swamps and even lakes have been drained, fields of corn and wheat have been sown year after year, and the whole broad face of Nature changed. Most of this has been done within this century, much of it in the last quarter. Have not such sweeping changes had a marked effect on the climate, causing great changes in the nature of the soil, the rainfall, and the temperature? Some argue, with great show of facts and figures, that it has; others, with equal force and greater positiveness, that it has not. And either side may be right, for the question is debatable. I maintain that the time has been too short, observations too few and limited, and investigation too biased for the problem to be determined one way or the other.

Not many years ago, as history is recorded, but a short lifetime, as men view time, there was an immense unbroken forest in Wisconsin and Minnesota. Through the denser parts of these forests were many considerable watercourses and large lakes. South and west of the great pine forest, in a belt of deciduous trees, were scattered thousands of small lakes, and, on the prairies beyond, many more lakes and innumerable marshes or swales. Forty years have passed and what is the present condition? Fertile but sometimes drought-stricken fields occupy the southern part and beautiful farms cover the belt of oak openings. But the swales are gone, and many of the lakes have totally disappeared. Others have dwindled until two-thirds, one-half, or less than a third of the original area remains. The streams have become so diminished in volume that with great difficulty the log drivers float their smaller logs of culled-out timber to the Mississippi, where formerly immense drives of the largest timber were made with ease. Every summer, reports of great and unprecedented heat and long periods of drought fill the newspapers. Has there really been a change in these conditions? And, if so, was it not the forest clearing and cultivation that did it?

The old settlers will instance the above changes to you, and scarce one of them but believes the clearing and settling up of the country has accomplished them. The writer was born in Minnesota and lived there from infancy to early manhood. He has the evidence of his eyes for proof of the diminished streams and lakes. He believes, too, that the rainfall has lessened, but does not know, for there were no rain measurements in the forest regions in those early days; but the rainfalls seemed much heavier in his early boyhood than twenty

years later, when he measured them at the station in St. Paul. However, personal impressions are not a safe guide in such matters. Reports were often rife of temperatures in the nineties during the early days, but there were then few standard thermometers and fewer proper exposures. So there is no evidence that the summer temperature has not increased and none that the summer rainfall has not decreased. In the early records of the frontier forts and the French trading posts I have not a great deal of confidence.

In the far Northwest, from the western slopes of the Cascades to the seacoast, fed by moisture-laden air from the ocean and the heavy rains precipitated on these slopes, there sprung up long ago the mighty, almost unending forests of gigantic trees. These great conifers, that have given to one of our Union the title "Evergreen State," were twenty-five years ago scarcely touched by the hand of man. In a few short years the ravages of the axe, the gang saw, and, greater still, forest fires, have been so vast and alarming that the National Forestry Association felt impelled to secure an executive order setting aside great areas, large enough to form small States, as permanent forest reserves. Their fear and argument was not solely the commercial effect of the loss of the timber as a source of wealth, but also a disastrous effect on the mountain streams, lakes, and the soil of the country; perhaps, also, on the climate.

Even those who deny any appreciable meteorological effect admit disastrous effects on the soil from wholesale forest clearing. The presence of forests retards the melting of winter snow, which otherwise melts suddenly, allowing the water to rush in great volumes down the slopes, resulting in damaging freshets. The roots of the trees hold the soil together, which otherwise would be moved by the rush of torrents of water, and rubbish, sand, gravel, and boulders washed down and deposited over fertile bottoms, destroying the value of the latter. In dry spells the springs and small streams dry up and disappear because the unsheltered soil is exposed to evaporation; much more so if the process of cultivation has upturned the bare earth where there would else have been a covering of grass or undergrowth.

Some admit even more, by allowing that evaporation, being retarded, and moisture held in suspension over the forests, more constant, moderate, and uniform rains occur, while extensive clearing makes the rainfall more intermittent and torrential. Long periods of drought occur, broken by excessive rains of very short duration. The climate, in short, begins to resemble that of the great treeless plains in the nature of its precipitation.

Some of the most noted meteorologists have maintained that a permanent decrease of average yearly precipitation or permanent increase of mean temperature is impossible as a result of forest clearings; they hold that the causes that contribute to rainfall over a large tract of country are of too widespread and general a nature to be permanently affected by such minor changes in the face of Nature as the removal of a forest growth or the cultivation of the soil. This is simply saying that general rainfall over a given area is the result of a moisture-laden wind from the ocean or large seas moving over or contiguous to that area, and that such a disturbance covers thousands of square miles in area and reaches high into the atmosphere; it has crossed mountain ranges, perhaps, without breaking up, and is not to be

swerved from its course by the presence or absence of forests. Very true; and none of us who have followed the daily maps would venture to differ from the leaders of meteorology on that score. But what humble observer with experience, much more the baffled forecaster, has not learned that even in great cyclonic movements rainfall is the most local of all things meteorological? What local forecaster has not predicted rain for his station on account of a general low-area storm, and yet "missed it," although he subsequently learned that copious rain had fallen not three miles away? So I believe it possible that the distribution of rain—monthly, seasonally, perhaps even annually—can, by forest clearing and cultivation, be changed over small areas, yes, even over whole States, though not whole countries like our Union of States. Nor is the latter necessary to my argument. Rain being of so local a character in the general cyclone, forests might well be a cause for condensing over their area or in their neighborhood continuous though gentle rains from even the feebler low areas, while the treeless tracts would receive only occasional, though perhaps excessive, rains from only those of decided energy.

Prof. William Davis says:

> Popular opinion is disposed to believe in an increase in the rainfall of our semiarid western plains by means of tree planting and agriculture, but no evidence in the form of actual records has been adduced to prove this very hazardous conclusion.

During his residence of some years in Utah, the writer became aware of a general belief that the settlement of Salt Lake Valley, and the general cultivation by irrigation and the planting of a great number of trees had had a noticeable influence in increasing the rainfall and water supply, so that if it went on there would finally be little need of irrigation. He was unable to verify this from records, but, as I have before indicated, the records previous to the establishment of the signal station there were very broken and uncertain, and would prove or disprove nothing. The testimony of the inhabitants was positive that several mountain streams, which formerly had gone dry in summer, were now permanent.

In the Evergreen State, where I have had the good fortune for some years to reside, and in the adjoining State of Oregon, there are, as you well know, two divisions of each State, more different in their climates than any two adjoining States you can name. The eastern sections of the States referred to are dry in climate, while the western sections are moist to wet. Warm, moisture-laden storm movements from the ocean, striking first the coast ranges, lose by condensation from adiabatic cooling in the ascent a large amount of moisture which falls as excessive rain during six to nine months of the year. Still eastward rain falls as it ordinarily forms by adiabatic cooling over the intervening country to the Cascades. There, in passing the mountain barrier, the greater part of the remaining moisture is precipitated by the same process of adiabatic cooling, so that but little moisture remains for the great plains of the Yakima and Columbia rivers, while the southwest to northwest winds, warmed by the double effect of liberated latent heat, and dynamic heating in descending the eastern slopes, become the chinooks of that section, like in character to the foehns of the Alps. And here let me digress merely to

repeat of those chinooks what Professor Waldo has so well said of the foehns:

> The degree of intensity in the foehn (chinook) depends on the amount of water lost by condensation high up in the mountains, and on the distance of the descent of the air. If no water were lost out of the air there would be no foehn (chinook).

Over the immense region west of the Cascades, then, the rainfall is heavy, and though it is doubtless true that such an immense forest area naturally grows up where the climate is moist and rainy, it is perhaps also true that the great somber forests have a reciprocal effect in making the regions more rainy. This is speculation to be sure, but it seems as though the great low-area storms have a peculiar tendency to linger over the forest region and western slopes of the Cascades, retarded often for days at a time with no apparent cause. Then, as with a bound, they pass the summits, and the low areas move rapidly to the east-northeast. In fancy, then, I see as a result of the disappearance of the great forests of Washington (as disappear they surely will at the present rate in three or four generations) a great change in the two contrasting climates. The storms will pass more rapidly across the western part of the State, precipitating less of their moisture, and appear east of the mountains with a greater amount, which will then fall over eastern Washington. Thus, the result will be beneficial, climatically speaking, and twofold; the western section now too moist will become less moist, the eastern section now too dry will become less dry, making fertile the arid lands along the Columbia. A consummation devoutly to be wished, you say, but too fanciful. Perhaps not. It is indirectly proven even now. For the past two or three years there have been unusually heavy summer rains in eastern Washington, contributing to unprecedented wheat crops. In June of 1897 the rainfall was singularly heavier east of the mountains than west of them. So also at times during the past summer. Why? Under what conditions did this anomaly take place? It occurred wherever the low area reached eastern Washington without being robbed of its moisture by passing over the western section. This happened when the area moved up from southwest Oregon, or rapidly up the Columbia Valley, or even when the storm passed without lingering across the Cascades. In such cases the east side always received its maximum rain. So I believe if we grant that forests have an influence in retarding storms, their clearing will result in changing the climate as stated. Some years ago a Nevada correspondent of the Salt Lake Tribune made this claim for Nevada, namely, that the clearing and burning of forests on the Sierra Nevada had increased the precipitation in Nevada.

Returning from the field of fancy to that of facts, and to the diminished streams, swamps, and lakes of Minnesota, it is not necessary to suppose a diminished rainfall to account for what we have noticed there. Forest clearing allows the snows to melt rapidly in the spring, the streams to rush away in sudden freshets, instead of a gradual flow through the summer. Cultivation of the soil upturns to the sun an immense expanse of earth from which the moisture evaporates, instead of having remained in the soil as it otherwise would. Many of the lakes, sloughs, and swamps of Minnesota have been drained for cultivation, and the writer well remembers seeing miles of ditches excavated during his boyhood. As Prof. Cleveland Abbe has aptly said:

Every acre of virgin soil that is plowed up and cultivated begins to evaporate into the air the moisture that it formerly conserved. Similarly every new drain that is dug helps the water that formerly staid in the soil to flow off into the rivers. The progress of agriculture begins by an effort to drain the rich lowlands that are usually too wet, and ends by the necessity of artificially watering both the dry uplands and the warm lowlands. In other words we begin by evaporating and draining off the water that we eventually wish we could get back again.

Professor ABBE. I think the quotation from Abbe is all right, but Abbe had in mind New England and European conditions. What he said is true for a large part of the world, but not universally.

Mr. HAMMON. Two or three years ago I read in Science a paper which is so absolutely contrary to anything I had ever read on the subject that I think it is worth discussing here. It was by a man from Nevada, and he declared that there was excellent evidence that the denuding of the forests of the Sierra has actually increased the water supply during the summer; he did give very good reasons for his belief and cited facts to show that the streams held their water in summer much better since the timber was cut off. The forests are of pine, and he claimed that the snow melts faster when the trees are standing than if they were not there. When the forests have been cut off all the snow blows into the cañons, hundreds of feet deep, stays there all summer, and keeps up the water supply. When the trees stood, it formed a blanket over the ground and melted much more quickly. Of course this is a local condition, but it is the region whence we get our water, and if the cutting off of the trees is going to increase our water supply in California, we shall be very glad to have them cut off rather than preserved.

Mr. SAGE. I have made the conservation of moisture in the soil a special study for twenty-five years in Iowa. I believe the effect of deforesting any area depends upon the geological formation and the character of the country. If it is a hard, rocky country, like some portions of the east, with an excess of rainfall, then to cut off the forests allows the soil to be washed away, whereas in our region the cutting off of the original forests has no appreciable effect whatever upon the surface moisture, in my opinion. I believe the subsoiling of our prairies, where we have humus 4 feet deep, prepares the soil to receive and retain moisture better than the eastern forest, with its hard subsoil. In other words, we can store away within our prairies, if they are properly cultivated, subsoiled, and drained, more moisture, and keep it through the season for the benefit of plants, than they can in any forest region in the east or north. I believe our subsoiling and our method of cultivating prairies is more than equivalent to covering with forests any area of the same extent; that is, with our deep soil. In the east I would advocate reforesting large

portions that have been deforested. But here trees act as robbers of the soil as well as conservators of moisture. Trees are detrimental in prairie farming sometimes. You can not get a row of good corn for two rods alongside a row of trees. So this question has a good many sides to it, and it depends altogether upon the locality and the nature of the soil whether forestry is important or not from a practical agricultural standpoint.

Professor HAZEN. This subject is of the utmost importance, and you gentlemen from all parts of the country ought to have some pretty clear ideas as to the effects of forests upon rainfall. While I do not believe that the presence of forests increases rainfall, yet I believe most emphatically that it conserves rainfall. Then if you have forests there will be springs. In New England the springs are drying up because the forests have been cut away. So, we have positive information there from the drying up of the springs of the effect of cutting away the forests. While I agree with Mr. Sage that the cultivation of the soil will prevent a good deal of moisture from going to the streams, it seems to me that at the same time this very cultivation will allow a greater evaporation, so that you lose moisture in that way. The very article in Science that Mr. Hammon referred to was answered by two or three individuals who showed that the effect of piling the snow into those cañons was simply to increase the flow of the stream out of the gully, but the larger area was drier than before. I say emphatically that the cutting-off of the forests would give us a dry land.

Mr. J. WARREN SMITH. I have in mind a spot on a mountain side in New Hampshire where there is a clearing surrounded by woods above and below. In the wood above the clearing, water stands in the streams all the year round; in the clearing it is all dried up; and below the clearing there is water also. I think the Weather Bureau should take up this question in a practical manner. Regular observation stations should be established and carried on long enough to determine this point. There is a difference of opinion on it. Stations of observation should be established upon streams flowing from heavily wooded sections and from districts where the old growth forests have been cut off. A record should be made of the precipitation, the flow of streams, the depth of water content of the snow on the ground, the condition of the soil under the snow, and the exact conditions preceding and following a flood. Record, and that alone, will determine the facts in the matter. The editor of the American Cultivator has contended that heavy forest growth consumes more water than it conserves, and that when the ground is frozen a thaw with a warm rain must precipitate a flood. Yet it seems very unlikely

that the ground would be frozen enough under a heavy forest growth to prevent water from melting snow to percolate freely into it in an innumerable number of places, and we are all sure that snow remains to an appreciable depth in the woods, when the ground is practically bare in the open and the underbrush.

The treasurer of the Amoskeag Manufacturing Company, of Manchester, N. H., said, in part in an annual report, a few years ago:

> On April 15, 1895, there occurred the highest freshet until then known in the Merrimac River. * * * We worked all that summer to repair the dam, etc. Had it not been for these repairs the dam and the gatehouse would probably have been carried away in the freshet of March 2, 1896, and all the mills in Manchester stopped for an indefinite period. As it was, the water rose one and one-half feet higher than the previous spring, carried away our bridges as well as the city bridge, compelled us to stop work and left 6,000 operatives without employment. When you consider that the Merrimac has for the past few summers been lower than in previous years, it is evident that some cause is at work turning the stream into a torrent, with long droughts and fearful discharges of water. There is but one explanation in my judgment, of this phenomenon, namely, the cutting down of forests around the headwaters of the Merrimac, the Pemigewasset and other affluents. * * * I appeal to you, gentlemen, for the interest of New Hampshire, which depends so much upon the success of the manufacturing corporations situated upon the Merrimac and the other streams of the State, to exert your utmost influence to induce the next legislature to protect the forests remaining. The damage done is already most serious, and if this state of things continues, manufacturing by the water power of the Merrimac will become, in my judgment, impossible in New Hampshire. * * *

Mr. Sage. Not only does deep cultivation allow the soil to take up moisture, but the stirring of the surface keeps it there. In other words, you put a cap over it when you have it there. That is where cultivation comes in to conserve moisture.

Mr. Mitchell. This is such an interesting question, and there are so many varied sides to it, that I would like to cite the experience of one of our voluntary observers in Florida. He has lived in Florida forty years, and came to my office purposely to ask a question relative to the conditions we are discussing. He said that for twenty-five years, to his certain knowledge, there had been small lakes in that country, which is flat, over which he had to travel with his cart, but within the last five years this water had disappeared entirely and there was now none to be found. These pools had dried up and yet the annual rainfall did not show any deficiency.

Mr. Bailey. In Fort Smith, since I have been there, I have talked with some who are interested in the river reports, and they state that they used to have a regular general rise but do not have it now. The engineer of the Government at Fort Smith said they never have had a regular general rise in the Arkansas River. I have never had a chance to examine the statistics to see which is right.

Mr. Hammon. Regarding irrigation in our State and its effect: In a normal season Tulare Lake does not cover one-third of the area it

did twenty years ago, because of the draining away of the water for irrigation purposes. This year there is no lake at all. When they first began to use the water for irrigating purposes, the people down stream protested. It became a great subject for legislation, because the people farther down would be without water. It is a fact that when the water from rainfall meets the permanent supply of water in the soil, which is only a few feet below the surface, we get a crop in California. When a space of dry earth remains between the two, we do not get a crop. Now the result of draining the water of these streams from along the foothills for irrigating purposes has brought that low water much higher, so that the old beds still hold water lying in pools all summer long when twenty years ago they were perfectly dry, and we get a crop now with decidedly less water in places not irrigated, than used to be necessary.

Mr. Bate. A few years ago I traveled through California and spent some time in the San Joaquin Valley. I was particularly interested in that raisin country. I noticed round the city of Fresno miles and miles of the old irrigating ditches that had been dry for years, and the man who was with me said they had brought the water there years before, but found they had too much for their vineyards and turned it off. That country was absolutely dry, and yet it was one of the grandest vine-growing countries I have ever seen.

Mr. Bailey spoke of a "June" rise in the Arkansas. A residence of several years on the lower Mississippi and close observation of conditions on that river, impressed him with the effect of a "June" rise on the country and the crops. The cotton planters had a very wholesome dread of a "June" rise. Floods in the river caused by spring floods above on its tributaries were not so much dreaded, although sometimes they caused a greater overflow; but when a general rise came through the melting of the snows in the Rocky Mountains, the conditions produced were most disastrous; something like the flood of last year.

Mr. Brandenburg. We need never fear a disastrous flood from melting snows in the mountains unless we have heavy rains to produce melting. Natural melting without rain never causes a flood.

Professor Moore. This subject is such a fruitful one that we might profitably continue its discussion for a week. It is extremely difficult to base any conclusion on mere hearsay evidence. Old citizens will come in and tell you a stream is dried up or the water in the well is not so high as formerly, and all from their own recollection. Unless you have accurate data to discuss, it is utterly useless to attempt to reach any conclusion. Now, Mr. Mitchell stated that a number of

ponds in the State of Florida where the land was perfectly level had passed away. It is certain that if there were ponds, there were also depressions which caused drainage in their direction. Now that drainage, although the movement of water was slight, carried alluvial deposits into the depressions. These deposits, with rank vegetation, have simply filled up the ponds. The water is there, but below the surface of the earth. A mistake that most people make, in claiming that there has been a change of climate in their region, is due to the fact that change is continually going on in the surface of the earth, due to the action of temperature and water. That is what causes your streams to fail and your ponds to pass away. Now, you may drain with tiling and other methods and you will alter the character of a small area; but I venture to say that all the draining done in the United States and all the deforestation have been immaterial, inappreciable, in their effects on climate. They may have had an effect in augmenting floods, by rendering it possible for a given amount of water to gather more quickly, and thereby supply streams with a greater volume to carry away in a given time, producing flood stages. I can see practically no other effect of deforestation or of the drainage of the surface of the ground by tiles than simply to augment the intensity of the flood volume. It has no effect on climate. But the subject is such a fruitful one, as to what is the effect of forests on the conservation of moisture and the effect of the cultivation of forests on the consumption of the moisture in the soil, that it is a grave question whether the planting of forests does not result in the consumption of more soil water than the foliage retains by shading. There has been much written on this subject, and it is nearly all on very imperfect data, and we have very few facts on which we can talk with any certainty; but it is so interesting that I encourage you to study the subject in your sections. Don't take hearsay, and don't take what the oldest inhabitant says.

Mr. Sage said there was a great lack in many States, and especially in Iowa, of rainfall data. One station in a county for rainfall measurement was not enough; we should have ten; if possible, one in every township.

TOPIC No. 11.—IS THE WEATHER MAP APPRECIATED AND UNDERSTOOD BY THE MASSES? WOULD NOT THE POSTAL CARD WEATHER FORECAST PROVE A SATISFACTORY SUBSTITUTE FOR THE MAP, EXCEPT WHERE IT IS USED FOR THE PURPOSES OF STUDY AND INSTRUCTION?

E. B. Calvert, Washington, D. C., and T. F. Townsend, Philadelphia, Pa.

Mr. Calvert. Mr. Chairman and coworkers: In a brief paper that is referred to elsewhere in our program I have treated of the development of the weather map. The history of this important work of

our service shows that the mechanical problems in connection with the weather map have been overcome. It is now possible to issue as many legible copies as may be required. But now another important question presents itself, one that must be considered carefully and intelligently. During the year ended June 30, 1898, over 5,000,000 maps were issued to the public from the stations of the Weather Bureau. They were sent to people representing nearly all the different lines of commercial and professional life. What percentage of these persons used the charts intelligently, understanding the drift of the highs and lows and the weather conditions that usually accompany them, and what percentage merely used the printed forecasts, ignoring entirely the map itself? These are difficult questions to answer, but they are vital questions. If any considerable proportion of the subscribers paid attention to the forecasts alone, then the less expensive and more easily prepared bulletins and forecast cards would have answered every purpose. For over ten years the weather charts have been issued to the public, and in every community they have been conspicuously posted. Are these charts better understood and more intelligently studied now than they were ten years ago? Our station officials may differ in answering this query, and their opinions will be interesting. For several years the Washington Evening Star published conspicuously a reproduction of the morning weather map. It was one of the features of that paper. A few months ago it became necessary to use the space for other matter and to discontinue the chart. It was fair to presume that in such a community many letters would be sent to the Star in regard to the discontinuance of the map. Only three such communications were received. Does this indicate that the public does not understand and appreciate the weather maps?

We have brought our map making process to a satisfactory stage; now it is important, as far as possible, to confine the issue to those who desire to make intelligent use of them and can do so. This is not an easy task. It is not possible to investigate each individual request and ascertain whether or not the chart to be furnished will be advantageously studied, or simply placed in a frame to be regarded as a mystery by the majority of those who stop to examine it. It might be advisable to discontinue the maps issued at small stations and replace them by bulletins, or forecast cards, without impairing the efficiency of the service, and at larger and more important stations to keep the issue as small as possible by a judicious inquiry into the uses to be made of the charts by applicants. It is possible in many cases to meet the needs of persons requesting the maps by sending them forecast cards instead. Most of our station officials exercise great care and judgment in this matter, but still the map list grows. This increasing demand might be taken to indicate that the public is becoming better informed in regard to the charts and their value. In some sections this is probably true, but in most instances it can be attributed to the desire of the applicants to get the charts because others get them and because they are furnished free. To those not acquainted with station work this argument may seem weak and insufficient, but the station officials know that it is true.

Since it has been decided to discontinue the use of the large size station map, and use instead the small chart, the aggregate cost of

the maps will be considerably decreased. This smaller chart can be prepared almost as quickly and cheaply as a bulletin, as but one small piece of stencil paper is required. This being the case, no material advantage would be gained by issuing bulletins at small stations instead of the maps, but if the predictions alone are appreciated by the public the forecast cards can be furnished easier and far more economically than either the bulletins or the maps.

The station maps in blank cost the Bureau about $1.55 per thousand, while the same number of forecast cards cost but 40 cents. The expense of preparing and issuing maps is far greater than the expense of sending out cards. It is not economy to deny the maps to those who can gain information and profit from them, but as trusted public servants it is incumbent upon us to use due diligence in their distribution and to guard against unnecessary waste. The whole matter is worthy of discussion.

Mr. Townsend. In answer to the question "Is the weather map understood and appreciated by the masses?" I would say, emphatically, no. Neither do I think they are by the majority of those who receive them. Most of the maps that are posted "for the benefit of the public" are placed in front of stores and other places for advertising purposes, and the public in passing look at them as they would a picture, and but few stop to study them. I believe, however, there are enough people that do and can make an intelligent use of the maps to warrant their distribution to the largest number practicable. The issue is necessarily limited, as they can not be prepared until the reports are received and the printing must stop before the closing of the mails. Because of this limitation, more care should be made in their distribution. A short time ago letters were sent out from the Philadelphia office to almost the entire mail list asking whether cards could be substituted for the maps, and nearly every answer was no, but they gave no reason for their answers. The maps are larger and nicer than the cards and cost more money, and when people can get something for nothing they want all they can get. I think there is one objection to the card as issued at present. A synopsis should accompany the forecast. In this way I believe it possible to get more people interested in the card. In order to give this additional information it will be necessary to stamp or print them in some form different from that in present use. The ordinary printing press is not fast enough. The inventive genius of the members of the Weather Bureau should be sufficient to get up some cheap instrument that will print them rapidly. Some means for addressing rapidly is desirable, and for this purpose I have constructed a device. I won't speak of its merits or demerits at this time, but would like to have you see what it will do.

(Mr. Townsend exhibited his addressing machine.)

TOPIC No. 12.—PAPER: PRIMARY WORK ON METEOROLOGY FOR THE USE OF SCHOOLS.

Patrick Connor, Kansas City, Mo.

Mr. Connor. My experience during the past year or two has led me to believe that the Weather Bureau should compile a small, primary

work on meteorology, suitable for the lower grades of schools, for free distribution to schools and teachers, or at the cost of production which, of course, would be very small. I have mentioned this matter to teachers, clergymen, scientists, and others, and all were of the opinion that the idea should be carried out by all means, some of them being quite enthusiastic, especially Prof. J. M. Greenwood, Superintendent of Kansas City public schools, and President of the National Educational Association of the United States.

In the first place, there is not a primary work, a catechism, an elementary handbook on meteorology to be had; certainly none that fills the requirements of present needs. Waldo's and Davis' works are all right in their place, but a pupil must be ready to enter a high school to take them up. There should be a simpler work to interest and instruct children in the earlier grades. Meteorology need not be altogether treated as an advanced study to be taken up only when the grade of a high school is reached. It is estimated that only about 4 per cent of the children of the United States enter a high school or other institution of similar or higher standing. Now, what is being done for the remaining 96 per cent? Even in the high schools meteorology does not come within the curriculum, except in so far as it is treated in physical geography.

During the year ending June 30 last, the Kansas City office furnished maps to 175 educational institutions by request, less than one-fourth being up to the grade of a high school course. Much information was also given by our office upon the text-books available, the usage and cost of instruments, and how the study could be taken up in the schools, but it requires more than can be said in a letter to give them a start.

Another lamentable feature of the matter is that very few teachers have a knowledge of meteorology. It is not required of them in in order to secure a teacher's certificate. They are not furnished with text-books, and a great many are unable to purchase them because of meager salaries. It may be set down that the teachers and principals will not take up, in an incidental way, the teaching of something of which they have but a poor idea and which is not outlined or systematized in any available work. The course suggested by Professor Davis is far beyond them. The study must be made easy and elementary. The introduction of this branch into school studies is an innovation that must be presented in a simple and attractive form.

Then, again, public appreciation of the difficulties met with in forecasting, a feature of the Bureau's work which overshadows all else, will never be secured until the public has a better understanding of the subject, and the surest way to bring that about is through the schools, which will act as a leaven in their several communities. I have explained time and again in the newspapers, as doubtless many observers have done, how forecasts are made; what they are based on and the difficulties which beset the forecaster, as well as the unreasonableness of the public at times, but a failure is looked upon by the masses at present as if nothing had ever been said or written on the subject, and the great majority are just as prone to credit it to inefficiency.

All of us have been benefited by what we have been taught in schools and colleges; but is it not amazing that the prominent educa-

tors, those who decide and dictate what branches shall be taught in the schools of the country, have not yet realized the importance or practical usefulness of giving pupils an idea of the atmosphere in which they live; the phenomena which concerns every day of their lives; that which sets its seal on character and modifies hereditary tendencies.

It is understood, of course, that the schools in a few prominent cities have taken up this matter in a rudimentary way, but this fact does not lessen the responsibility of those who prescribe the courses for the various States and Territories.

The majority of children who receive only a smattering of certain scientific branches forget all about them within ten years after leaving school, simply because there was nothing in their daily lives to refresh their memories or revive recollections of them. Take botany and chemistry: I doubt if one in ten, within ten years after quitting school, could tell which way the seeds point in an apple, or give the chemical designation of common table salt. Whereas, with meteorology it is quite different. Instead of forgetting what they had learned, their knowledge would increase—thanks to Nature's free lectures and daily panorama.

My idea in suggesting this work is that, besides being a simple treatise on weather matters, it should contain instructions for teachers which would enable them to interest children from 7 or 8 years of age up to where their mental equipment calls for a more advanced work, and I believe that the primary education in this line would make the subject so attractive that it would soon become one of the preferred studies.

The instruction should begin with symbols. The teacher, in order to engage the attention of children 7 or 8 years of age, should draw flags on the blackboard to indicate the expected weather. After they become thoroughly familiar with the flags and their meanings something else should be added. The points of the compass should be drawn, and across them an arrow showing the direction of the wind; and, as they become familiar with the points of the compass and the designations usually given the winds, a little more could be added; but the flags and wind directions should be kept up every day. Now the teacher could write, for instance: "To-day the wind blows from the north. The weather is coldest when the wind blows from the north or northwest." "To-day the wind blows from the south. The weather is warmest when the wind blows from the south." Interest should be kept up by adding something new every now and then, thus: "The sun does not shine to-day because of the clouds." "Clouds are made of tiny particles of water." The subject can thus be developed from this simple beginning gradually to cover the readily recognizable features of the storms of summer and winter. There should be a short and simple description of the barometer and how it acts before, during, and after a storm; in other words, its application to weather changes. The dry and wet bulb thermometers should come in for their share, and the significance of their readings be explained, thus: When the readings are far apart the atmosphere is very dry; when close together, very moist, as in foggy weather. With high temperature and not much difference in the readings, you may expect to feel warm and uncomfortable; the air is very oppressive, because it is very moist or humid. Sunstrokes may occur

in the neighborhood. But with the same temperature and the wet bulb reading 15° to 20° lower, you do not feel uncomfortable in a slight breeze, because the air is very dry. Further on explanations of these facts can follow.

At this time the children should be required to record daily the reading of the barometer and thermometers and the direction of the wind.

A general conversation should be given in the work on the physical aspects of storm areas, the names and elevations of clouds, and how clouds and rain are formed. The children should now be called upon to record daily, with other things, the names and amount of clouds and the state of weather.

It should be suggested that teachers should elaborate their explanations, which frequently prove to be very instructive outside the immediate point at issue. Frequent reviews should also be called for.

The titles of the best American works on meteorology to be read after this primary course should be given, and the cost; also, the cost of ordinary and good barometers and thermometers.

The daily weather maps and how they are made should be explained, how to compare them to get the sequence of changes, and an allusion to the many hidden beauties discoverable after a little study.

There is a great necessity for a work of this kind. Its issue by the Government will not be usurping the privileges of publishers or authors. It will be a parallel case with the issuance of other scientific and semiscientific papers, constantly being published, for public enlightenment. In fact, it is believed by the writer that it would stimulate the sale of standard works on meteorology, as very few teachers would stop investigations with the knowledge gained from this primer. The attractiveness of the subject would arouse interest in teachers and pupils who, perhaps, never would have understood the difference between a barometer and a thermometer if it had not been for this simple but valuable little book.

If the Bureau is anxious to have this study taken up in the schools of the country, this is the only rational and systematic method by which it can be accomplished.

Professor Greenwood, in a letter on this subject, dated July 25, 1898, says:

> The suggestion that a small volume be prepared by the Weather Bureau, stating explicitly the simplest principles of the science of meteorology for the use of the teachers and pupils in the schools of this country, meets my unqualified approval. I sincerely hope your efforts in this direction will receive consideration at once.

TOPIC No. 13.—SHOULD NOT CERTAIN IMPORTANT WEATHER BUREAU STATIONS, THE DUTIES OF WHICH COVER A WIDE RANGE OF WORK, BE DESIGNATED STATIONS OF INSTRUCTION FOR NEWLY APPOINTED OBSERVERS?

J. Warren Smith, Columbus, Ohio, and C. F. R. Wappenhans, Indianapolis, Ind.

Mr. J. Warren Smith. This idea of stations of instruction was suggested to us by the fact that our office has been burdened with new men this summer who, while unable to take hold of any important duties in a trustworthy manner, have actually made the older men more work by their inexperience. I believe that it is a detriment

to the satisfactory work of a station to have new men put in an observer's place and supposed to fill it, so far as the work of that office goes. The absolutely new man must make more work than relief if he is being properly instructed. The result of the present system oftentimes is that while, theoretically, the new man may be taught all the details of the work, he is actually set at that work which is simplest and which he can do most readily and rapidly, or which the older men dislike.

Perhaps he is first put on a small station with a limited variety of work. He does a portion of that limited variety of work in a highly satisfactory manner, is favorably reported on, and is sent to a large station as an experienced man, but he is like a new man to the latter station.

I believe that certain centrally located stations that have a great variety of work should be the centers of instruction, for instance, one west and one east of the Mississippi, and that when new men are sent there the regular office force should not be disturbed. It would be well to have certain men at these stations designated as instructors, who shall train the new man carefully, report on his progress to the official in charge, or directly to the Central Office, and then, in a measure, be responsible for the observer's fitness when he finally is given regular duties.

Mr. Wappenhans spoke briefly of the danger of entrusting even simple work to new hands and deprecated removing an assistant as soon as he had become skilful.

Mr. Bate. I heartily agree with the gentlemen who have made these very appropriate remarks. I have had a sort of kindergarten at my station during the present year. I have just finished with one pupil, and the happiness of this meeting has been marred to me, to a great extent, by the knowledge that I have to go back home and take another kindergarten pupil. My man, who had just finished his six months' probation, is ordered off to Santa Fe. I think it would be a decided economy to establish these proposed schools of instruction, and when a man comes to a station let there be some assurance that he will come fully equipped.

Mr. Mitchell thought the school was already established, namely, at his station. He would soon have a couple of graduates ready for some one.

Professor Abbe. I think you all must have been troubled by the changes in the young men. I can only wish that the Chief were here to hear these valuable suggestions.

TOPIC No. 14.—CLIMATE AND CROP SERVICE WEEKLY BULLETINS: SHOULD REMARKS OF CORRESPONDENTS BE PUBLISHED AS SUPPLEMENTARY TO GENERAL DISCUSSION? SHOULD WEEKLY REPORTS OF TEMPERATURE AND RAINFALL BE TELEGRAPHED TO SECTION CENTERS FROM SELECTED VOLUNTARY STATIONS?

A. E. Hackett, Columbia, Mo., and J. B. Marbury, Atlanta, Ga.

Mr. Hackett. In regard to publishing correspondents' reports, I have always thought that was one of the most important features of the bulletin. In Columbia I have met quite a number of the farmers of Missouri, particularly the more progressive ones, who come to the university to attend the short course in agriculture, which lasts two or three months during the winter. I have shown them copies of the bulletin and asked them what they thought of it. Almost without exception they have said that the reports by counties were the most interesting and valuable to them. The summary, which is placed at the top of the bulletin and which is published by the newspapers, gives a very good idea of the general conditions over the State for one who wants to read hastily and get a general view of the conditions, but many farmers are interested not only in the State at large, but in particular crops cultivated principally in certain sections, and they want to see what the reports are from those sections. I think the publication of extracts from their reports is of fully as much importance as the bulletin itself. But as to the best method of publishing these reports I am a little in doubt. Prior to this year I used to take the crop reports as they came in and place them together by counties. Then, in writing up the bulletin I took the reports from each county and tried to take one sentence from each man's report, putting in something like "Corn is doing finely," or "Too wet to plant," and so on. I tried to get a short sentence out of each man's report, something he would recognize, and published only the name of the county, not giving the name of the reporter at all, nor the name of the place. Up to this year I had about 300 to 350 names on the crop reporting list. Of course we all know a great many correspondents do not make reports regularly, and others are as regular as clockwork, but I seldom had occasion to drop from our bulletin mailing list, a man for failing to report. If he reported twice a month I kept him on the list, rarely having occasion to drop one. This year the list was increased to 500, and I think about the 1st of June I began to publish the names of the correspondents. I had room in the bulletin for about 76 reports; there are 114 counties in the State, and consequently I could not give the reports for each county, so I took them in rotation and the correspondents' reports in rotation, stating in the bulletin that that would be done. Our bulletin fills the entire sheet, the summary being set in solid primer and the correspondents' notes in solid minion. I published the name of the county, the name of the place from which the report came, and the name of the correspondent. This prevents any misconception or misunderstanding that might arise under the other plan of publishing only the name of the county, for it frequently happens that the conditions in one part of the county are entirely different—perhaps just the opposite of those in another; a man in the north part may report that corn is suffer-

ing for rain, while in the southern portion there may be an abundance of moisture. In such a case, if only the name of the county is published, the people in the southern portion are very likely to say that the report is not correct, and that the bulletin is unreliable and misleading, but when the name of the place is published such adverse criticism is avoided, and the publication of the correspondent's name not only gives him due credit for his work, but tends to make him more careful and conservative in his statements. But while I thought the change from the old plan a marked improvement, I very soon found a decided falling off in the reports. Correspondents could not understand why their reports were not printed, and they wrote and wanted to know. I had to write a great many letters of explanation, and even then a good many thought they were slighted.

Mr. MARBURY. The great value of the weekly crop bulletin lies in the fact that it carries to its readers each week the condition of the various crops, showing the effects of the weather, whether for good or evil. Now, the question arises what is the best form in which to present this information? Whether by a general summary of the conditions of the entire State or a condensed summary followed by the remarks of individual correspondents. That there seems to exist a diversity of opinion as to the best means of giving this information to the reader can be seen by a glance over the bulletins of the different sections of the National Climate and Crop Service. That there should be some uniform style adopted is beyond question. The general summary but vaguely expresses the true state of affairs and gives but little idea as to the location. The publication of individual reports is, in my estimation, by odds the best plan if sufficient space can be given to each correspondent, but to do this would require more space than is available in a bulletin of the size now in use. Many of the States contain more than one hundred counties and with several reporters in a county it would be impossible to publish remarks from each in a bulletin of the present size. As one means of overcoming the difficulty and at the same time covering the ground more thoroughly than could be done in a summary, I would suggest that each individual crop be treated under the proper heading similar to what has been done by the New England section. In this way full weight can be given each report as well as a clear idea as to the true condition of each crop. The chief, and I may say the only objection to the publication of reports by counties, lies in the fact that it is impossible in most cases to give an intelligent idea of the crop conditions, owing to the limited space available. The method adopted by some directors of publishing the reports in rotation, I think, is objectionable; it breaks the chain of evidence which should be continuous from week to week during the entire growing season, besides it not infrequently causes dissatisfaction among the reporters who feel slighted to find their reports left out. From my experience I am convinced that it is far better to have from one to two reliable reporters well located in a county than several. Within the limited time between the receipt of the cards and making up the bulletin for publication it is impossible to do justice to more than three hundred reports. I would suggest that the number of correspondents be not more than two to a county, and that as far as possible each county in a State be represented.

It has often occurred to me that there should be certain most favorably located points from which weekly reports of temperature and rainfall should be sent to the section center for use in the compilation of the bulletin. In order to reach the section center in time for publication many of the cards must be mailed on the Saturday before. Between the departure and arrival of the report some sudden and decided change may occur in the weather as well as the condition of crops which can not now be always known by the director. With telegraphic reports it would be possible to publish the normal conditions, together with the departures therefrom, which would afford excellent opportunity for study. There may be some difficulty in securing the desired cooperation at first, but valuable results would soon be realized, and after a short time this trouble would be overcome.

Mr. Cline. The weekly bulletin is one of our most important publications. I believe our bulletin represents a greater proportion of any one interest in the States than the bulletin of any other State. It represents one-third of the cotton produced in the United States, and of course it is closely watched by the dealers, not only throughout the United States, but throughout the world. The substance of our bulletin is cabled every week to Europe. Now I consider it a very important matter to publish the correspondents' remarks. The general summary will not suffice, because the local merchant is continually advancing money on the crop in different parts of the State and he not only wants the general summary for the entire State but he wants to know what the conditions are at every individual point. We can only give him this from correspondents' remarks. Another thing, the newspapers know what kind of information is valuable to the public, especially the daily press, which is crowded for space. Take the newspapers and ascertain what space they give to your bulletins, and you may judge of the value of the information you are giving in it. The Daily News, published at both Galveston and Dallas, and the Post, published at Houston, publish all our correspondents' remarks, sometimes running as high as three columns. That shows the value they place on this item. I consider the correspondents' remarks one of the most valuable features of the bulletin; that is, to the broker and the producer. I publish these correspondents' remarks by stations, and try to bring them in by rotation in different sections, as far as possible, so as to give them all a chance. It would be impossible to publish the entire list of correspondents for Texas in any one bulletin; it would take one printer three or four days to get it done. But we can take say sixty or seventy-five places well distributed over the cotton-growing portion of the State and give sufficient information to guide both the broker and the producer. I believe I can say nothing further in this connection, but I think we should make an effort to publish correspondents' remarks as far as possible.

Mr. BATE. I consider the weekly climate and crop report the great publication of the Bureau. I am happy to say that during the past year the weekly climate and crop bulletin work has been more highly complimented than ever before. As to the publication of the individual reports, I think that is much more satisfactory to the people who send in the reports, and also much more satisfactory to the public. I always supplement the observers' report by a short summary.

Mr. JENNINGS. The most important part of the bulletin is that devoted to the individual or county reports. I was never so forcibly struck by this as when, a year and a half ago, the usual letter came, requesting a summary of so many words to be sent by such a date, to the Central Office, so that it could be included in the March bulletin. I went down to the Secretary of the State Board of Agriculture, and asked permission to use his reports and get the addresses of his correspondents. "Why," said he, "we have quit. We have no use for any reporters since you have been getting out that bulletin in that way." So I went down to the office of the Kansas Farmer, where for years they had been getting reports from special correspondents, and they too had quit. They considered our report better than anything they had ever had. That shows the value placed on these county reports by the people at home, and to go to work and cut them off is, in my judgment, to cut off the most important part of the bulletin. You know Kansas has the reputation of being plastered all over with mortgages. Well, every big trust company in the east takes these bulletins of ours, and they use them for getting information needed in their line of work, depending very largely on these individual or county reports. There are large wholesale establishments which have men traveling over our State. They want these reports, and they want the county reports. It enables them to judge where best to send their men this year or next year. If they have a dry spell in any part of the country, they don't care to place many orders there. So these county or individual reports are considered in all parts of the country as the most important part of that bulletin.

Mr. MCGANN. I think every section director should issue a crop bulletin that he knows will meet the approval of his State. Each State has its own interests; you could not well have New Jersey following the lead of Alabama, or Alabama following New England. Each section director should do the best he can. In New Jersey we want individual reports, and in order to protect themselves from the speculator, the farmers don't want anything to do with the summary. The individual reports are the most valuable part of the bulletin.

Mr. Bauer thought but little credence was placed by chambers of commerce and different commercial bodies, except in a general way, in the individual reports of crop conditions in different sections. He believed it well, however, to publish reports of correspondents, as it encouraged them. He thought more attention should be given to the meteorological features of the bulletin, and particularly to the matter of rainfall, and that we ought, if possible, to provide crop correspondents with rain gauges, so that we would get full and complete rainfall reports.

Mr. Hammon, speaking on the second subject of this topic (No. 14) said that in some States it was absolutely essential to use the telegraph. If he did not use the wire in California for this purpose, he would never get the bulletin out in time to be of any use whatever.

Mr. Chaffee also thought that every section director could use the telegraph to good advantage.

This concluded the afternoon session and the Convention, at about 6 p. m., adjourned to meet at 10 a. m. the following day.

FRIDAY, OCTOBER 14, 1898.

The closing session of the convention was called to order by Professor Abbe at 10 o'clock a. m., October 14th.

TOPIC No. 15.—FROST FIGHTING.

ALEX. G. MCADIE, New Orleans, La.

Mr. MCADIE. An apology must be made by the writer for presenting a paper which is little more than preliminary in nature. The wish to make known the results of experiences in California, for the benefit of localities where the frost period is not yet over, has prompted this paper, and must be an excuse for such a brief presentation of important features of the problem of frost fighting. No one living in California during the past winter could fail to be impressed with the magnitude of the interests affected by frost. True, there are other critical weather conditions which affect the welfare of the community to a greater degree, such as a steady prevalence of hot north winds in May and early June, burning the grain when it is full of milk, or a deficiency in rainfall during the germinating and growing periods, December to April, so marked that cattle perish for lack of feed and all vegetation suffers. But, speaking generally, the subject uppermost in the mind of the fruit grower from the beginning of December to the end of March is FROST. When one thinks of the vast fruit interests, both citrus and deciduous, centered in this State, and realizes that the toil and expenditure of a year may vanish in a night, he can appreciate with what interest every step in the campaign to free the fruit grower is followed.

Unusual atmospheric conditions prevailed last winter in California.

No better opportunity to test certain theories and propositions connected with frost-protecting methods could be wished for. Moreover, a certain measure of success had rewarded a limited number of orchardists who had followed, in the previous winter, the suggestions of Mr. W. H. Hammon and others, demonstrating the possibility of protecting against frost even in the coldest weather likely to occur in California. The Weather Bureau office at San Francisco for two years lost no opportunity of emphasizing the following points: 1st, that frost could be successfully forecasted; 2d, that fruit growers could be warned in ample time to perfect arrangements for energetic and wide-spread smudging; and, 3d, as a result of the other two, that fruit growers could save the loss due to frosts, hitherto accepted as unavoidable. Valuable articles upon both theory and practice of frost protection were published and the whole matter brought prominently before the public. Many orchardists have experimented and much practical information is the result. At Riverside, the Horticultural Club appointed a committee to secure data showing the relative efficiency according to practical tests of the various protective methods, viz, smudging, moist smudging, steaming, dry heating, screening, flooding, etc. In brief, the results are:

1st. That the temperature of orchards can be materially raised by dry heat.

2d. The radiation of the earth's heat can be materially lessened by moist smudges started early and properly managed.

3d. Raising the dew-point by means of steam producing devices was not successful. (But this conclusion may not apply for localities elsewhere.)

4th. Cloth or mat covering is effective but expensive.

5th. The temperature was invariably higher in old seedling groves, or where tall windbreaks afforded to smaller fruit trees a like protection, than in exposed orchards. A tall well located windbreak is an advantage, but one not properly located may be a disadvantage.

6th. The temperature 20 feet above the ground was 1° to 2° higher than at the surface; at the height of 50 feet the temperature was from 5° to 10° higher than at the surface, when the air was still. When the air was in motion, the difference was slight.

7th. Coal baskets sufficiently numerous proved the most effective protectors. Oil pots make a hotter fire, but the deposit of lampblack upon tree and fruit is objectionable.

The whole report of this committee is of the greatest interest, and should be read by all fruit growers. For orange and lemon growers it is a most valuable paper. Figures showing the cost per acre of effective protection are given.

These experiments were made in the heart of the great citrus belt of southern California. Measures which are of greatest efficiency in this region, however, may not be well adapted to other districts. The protection of citrus fruits also is somewhat different from that required for deciduous fruits, grains, cranberries, and garden truck. To the report of the Riverside Committee we may properly add the following general consideration:

8th. The method of protection having the highest efficiency will not be the same for all localities and conditions. Each grower must determine for himself what method is best suited for his particular farm and crop.

Beginning almost with the first day of December, the season was characterized by frost. In time we shall probably know of some relation between the position of the permanent high-pressure area over the western portion of the country and the prevalence of low temperatures and heavy frosts. The pressure distribution for December is shown on Chart I of the report. The motion of the surface air out from the high area can be best understood by using, in connection with the different charts of pressure conditions, the relief map of southern California. Specific maps preceding frosts are Charts II and III, the former preceding by twenty-four hours the frost of December 3, the latter, the frost of December 20. A general similarity exists in the pressure distribution on both dates. Not every map of this type, however, will be followed by frost. The most important relation yet determined in forecasting frosts for California is one first pointed out, so far as the writer knows, by Mr. W. H. Hammon, namely, that the movement of a wave of falling pressure from Montana or Idaho southward across Utah and westward through southern Nevada and thence into Arizona or southern California, followed by a quick rise, is a good indication of much colder weather in the citrus belt. Given then a circulation of air typical of a frost condition, can we explain the localization of frost as a consequence of air drainage? The cold air is shown to move from the northeast, i. e., from the regions of freezing temperatures to the comparatively warm true citrus belt. Conversely, when the air moves from the warmer sea eastward over the land there is little danger from frost. Indeed, the second law in frost forecasting for California is that a breeze from the south or west will prevent frost in the citrus belt. An example of this was shown on the morning of December 3 at San Bernardino, where at 6 p. m. the temperature was 42°; at midnight, 30°; then a slight wind sprang up from the southwest, and the temperature had risen by 2 a. m. to 36°, and the danger of frost was over.

If we could follow the air as it moves, we should doubtless find a close agreement between the frost belts and certain drainage channels. An attempt to do this has been made. Mr. Frank H. Olmstead, for the Los Angeles Daily Times, surveyed the frost localities in Los Angeles, Riverside, San Bernardino, and Orange counties, and plotted these upon a relief map. The relation between air drainage and frost formation is quite apparent. From all of these investigations the following deductions can be drawn:

1. Where the air was in brisk motion the damage from frost was slight.

2. Stagnant air, such as would exist in low valleys, basins, inclosed patches, etc., favors frost.

3. Cold air draining into a region where there is an ascensional movement may give rise to frost streaks, Hence, large fires are not, as a rule, advantageous, as they simply facilitate the ingress of cold air.

These deductions make it plain that frost is not a haphazard matter, occurring without reference to physical laws and beyond explanation. On the contrary, every seeming contradiction, when carefully studied, will show some natural law at work, and that the results are in accordance therewith.

It would be of the greatest value to determine experimentally what the vertical distribution of temperature is at times of frost. It is known

that the isothermohyps (equal temperature heights) are complicated at night near the ground, because of the inversion of temperature with increase of altitude. It has been found by experiments with kites (Blue Hill Meteorological Observations. Explorations of the Air by means of Kites, pp. 100, 112) during cold waves at Blue Hill, Mass., that there is a fall of temperature with increase of altitude at the adiabatic rate (1° C. for 100 meters) from about 300 meters upward. Below this height it is more rapid. This is said to be the especial characteristic of the cold wave during the day; but the night curve, notwithstanding excessive radiation, is said to show a rapid decrease of temperature from the ground upward. The fall of temperature is not so rapid near the ground in the night as in the day. These departures from the normal rate are full of significance at times of frost. Perchance by their aid we may yet be able to foretell with certainty the coming cold wave, and also find in them clues to improved methods of protection against frost based upon a utilization of the heat already present in the atmosphere, but now lost because of imperfect mixture.

TOPIC No. 16.—AERIAL OBSERVATIONS.

G. B. Wurtz, Pierre, S. Dak., G. Harold Noyes, Topeka, Kans., J. C. Piercy, North Platte, Nebr.

Mr. Wurtz. In describing the results of the aerial observations carried on by the Weather Bureau during the past six months, I must confine myself mainly to the experience of a single station, but I take the liberty of adding a few fragmentary results which I have learned from others.

The work at Pierre was taken up late in the spring of 1898, and, while nominally under my supervision, was directed and conducted entirely by Mr. Orville C. Burrows, assisted by the kite reeler. In the matter of directing special efforts to some particular line of work, or to probing into some partially understood phenomenon, aerial observers were empowered to use their own discretion and inclinations as to methods in this scientific research. These men have done good work, considering the attendant circumstances; the majority of them were employees of but two months' experience as observers when they began the work. This short apprenticeship was devoted principally to the mastery of the mechanical problems incident to flying kites of large dimensions at high altitudes. I dare say that inexperienced men had to be put at this work because more experienced observers could not be spared from other fields; but, for this very reason, it could not be expected that the results of their labors should be startling in their meteorological revelations. That some tangible results are apparent is a great credit to these men, some of whom could not have appreciated the general scope of the meteorological science for which they were attempting, as it were, to blaze new paths to knowledge in the wilderness beyond. Indeed, their position is like that of one inexperienced in woodcraft attempting to survey and bring back an accurate idea of an unknown forest, or like that of a high-school boy trying to diagnose and explain the mysteries of some unknown disease. I say, then, that credit is due these men for obtaining any valuable information whatever by their work. While these results amount only to crude suggestions as to

the paths for more careful research, I feel confident they are worthy of considerate attention.

Perhaps, no more important demonstration has been made than the fact that the apparatus thoroughly fitted for one station is sometimes not adapted to the needs of another. To my mind, the experience at Pierre demonstrated that the first kites supplied were not strong enough for the winds. Even a smaller kite—one of scarcely more than half the surface—has been found too large for use in some of the winds, and many good ascensions have been cut short by the increasing pull on the wire. It is evident that to get the best results, the kites must go up in as many kinds of weather as possible. A lack of wind is an insurmountable difficulty, and strong winds are likewise often beyond the capacity of the present outfit. During the month of September, more observations were lost at Pierre on account of high winds than light ones. Bad weather and electrical currents of high potential have not interfered materially.

One of the difficulties we had to overcome was the breaking of the safety wires from sudden gusts, before very great elevations were attained, when convectional currents were playing an important part in the circulation. When the safety wire breaks under such circumstances, the ability of the kite to lift is so reduced that a good ascension is out of the question.

I invented a device to overcome this trouble from sudden gusts, without permanently changing the inclination of the kite. It was so constructed that at any pull up to some predetermined tension, as say 65 pounds, the angle of the kite would remain the same as normally bridled. After this tension was passed, however, the angle would decrease and thus usually allow the kite to overcome the effect of the gust and again resume the normal angle. If the critical strength of the safety wire was reached with the kite at the lesser angle, then it would break, and the kite would have to continue flying at the lesser angle. A two weeks' trial of this device resulted in no safety wires being broken, while previously the breakage had been nearly one to each ascension.

It has frequently been found that when moderate currents prevailed above and the surface winds were too high to admit of sending up the larger kite, the smaller one would not properly take up the sag in the wire, yet cumulus clouds showed good currents at slightly greater elevations. The trial of a small diamond kite under such conditions showed an increase of 3° in the angle of the kite and also of the wire at the reel, while the pull was almost inappreciably increased. In flying tandems, it is also possible, when conditions are favorable, to increase the surface exposed to the wind, or on the other hand, to take in a portion of the canvas when the pull is too strong. It needs no explanation to the kite-flier to show the advantage of having the lower two or three thousand feet of his wire well up off the ground, the trees, and the surrounding chimney tops. It is a decided advantage too to be able to take off one-fourth of the pull after one-third or one-fourth of the wire is reeled in when the dynamometer exceeds 65 pounds. For these reasons, I am inclined to advocate the use of tandem kites, but only when it is done to help out the first kite or pilot. If one kite will take the instruments above 5,000 feet, that is enough, to be sure, but if it will not, I say put on two, three, or more kites as may be required to make an observation.

In this connection, an appliance for attaching the tandem to the main line without impairing its strength and in such a manner as to be readily removable is a necessary precaution. Several more or less satisfactory devices have been used by those accustomed to fly kites in tandem.

But these mechanical improvements are of little use, unless we find them the means of making valuable discoveries for broadening our knowledge of meteorology and improving our forecasting. Our observations at Pierre apparently developed several "sure signs." They may have been local ones, but I believe they will bear fuller investigation. If they are forerunners of general disturbances, as I hope and believe they are, they will be of great value to the forecaster.

We had been accustomed to seeing a daily weather map at other stations. We received no reports at Pierre but we could not overcome the habit of looking daily for the basis of a reliable forecast, and we found one more reliable in the results of our kite work than in all other data obtainable.

When, at an approximate elevation of 2,500 feet, we found a stronger wind than at the surface, we knew almost certainly that we should have it at the surface before the day was over. Now, it is true that wind velocities depend to a considerable extent upon the barometer changes, and the steepness of the gradients, but there are times in the Dakotas when quite marked depressions pass without much wind, while at others some of the most disagreeable dust-storms occur when least expected. It is noticed that when the barometer leaves us in doubt, the kite reveals the truth.

The wind velocity at a considerable elevation would also show regularly a more marked variation in the velocity from morning to noon than was exhibited at the surface. Sometimes this variation would be a decrease so great that the kites would not remain up, and sometimes it would be an increase. This increase or decrease occurred as regularly as the sun rose from horizon to zenith, but I could not satisfactorily connect it with other phenomena. There appeared to be no means by which could be foretold the way the change would occur. Also, when the conditions above were not of the extraordinary type that later showed themselves at the surface, there appeared to be no close association between the changes of wind velocity at the ground and in the higher air. If this were better understood, I surmise that it would exhibit some interesting facts relative to the effects of insolation upon the cyclonic circulation.

We noticed early in the summer that sometimes there were inversions of temperature through the first 2,500 feet of the atmosphere and slight decrease of temperature in the continuation of the ascent. Sometimes these inversions were marked—the temperature 2,500 feet above the ground being from 15° to 18° higher than at the surface. These occurrences were invariably followed by a hot wave, and the heat usually became high at the ground by the middle of the same afternoon, and surely so by that night or the next morning.

Another observation was that when all the other conditions are indicating rain, no rain, or scarcely any, falls when there is even a slight upward tendency to the thermograph trace in passing through this layer of 2,500 feet.

Conditions were not favorable during the summer for noting the peculiarities of the thermograph trace with reference to cold waves.

The changes to cooler weather approximate more nearly a return to normal temperature, or only slightly below. What the winter observations will reveal in regard to the advance of cold waves, I am unable to anticipate, but I do look for some valuable results.

Some characteristics of Dakota climate might well be taken into consideration in this discussion. Often rainy conditions are apparent in the atmosphere, but with the rain clouds floating at much more than an average elevation. Not infrequently rain is plainly visible falling in a heavy shower from cumulo-nimbus as they pass across the country, yet evaporating before it reaches the ground. The falling rain appears like a vast fringe, well-defined at the base of the cloud and depending to some distance below it, but growing lighter, and toward the ground disappearing in mist. I know this is no optical illusion, for I have made careful observations of such clouds as they approached, passed directly overhead, and on to the other side with the same appearance still remaining. When the cloud is directly overhead, its form is hazy and indistinct, and its distance very hard to judge. It may be said that at this time one feels that he could almost touch it, and at the same time is uncertain but that it may be very far away. These clouds always come from the west. And now to seek the cause of this phenomenon. The atmosphere, so laden with moisture that rain must occur, and yet so dry that the showers evaporate before reaching the ground, is indeed a strange condition. One hundred and eighty miles to the west of Pierre and the Missouri Valley are the Black Hills, and when westerly winds, moisture laden, pass over this range, the entire current is deflected upward from 4,000 to 7,000 feet above the sea. The Missouri River is some 1,400 feet above the sea. Midway between the Missouri and James rivers, therefore, to the eastward of Pierre, there is higher ground, which slopes gently toward the two rivers. Eastward of this high ridge there is considerably more rainfall, and it appears quite plausible to me that the upper main current of air flows some 2,500 feet above the earth at Pierre, while the underlying air remains in this basin or comes from some other source. May it not be that some of the cross currents that sometimes give us trouble with our kites at an elevation of about 2,500 feet above Pierre are the eddies set up between these two layers of the atmosphere where they come in contact? May it not be that at this height we shall find the storms nearly continuous? Whereas, the surface observations make it appear that they are broken up by their passage over the mountains and their intensity decreased thereby. This hypothesis should, I believe, be taken into consideration in studying the causes of the foregoing phenomena. Intelligent handling will make these kite observations of value to the forecaster, but to do this they must study with that same delicacy of perception that the good physician does the symptoms of his patient.

Our forecasting has now reached a stage where improvement must be made, not in the ascertainment and recording of new elements or meteorological conditions, but in a more delicate and skillful diagnosis of those we now consider on our charts, An improvement of 5 per cent in the percentages of verifications means the elimination of nearly one-third of the errors.

Mr. Noyes. On the 27th of April, 1898, the first ascension of the

Weather Bureau kite was made at Topeka, Kans., and since then ascensions have been made continually.

A discussion of the results obtained at one station must necessarily be limited; it can, however, be carried on with a degree of profit, confining it to those points which are open.

In considering aerial observations, one of the first noticeable features is the action of the kite and the disclosures it makes of the wind's movements. On the ascension of a kite in a steady surface wind of 12 or more miles per hour, it is noticeable that the kite passes through a stratum of wind of very perceptibly greater velocity than that at the surface and than that in the stratum above. Now it is known that the obstructions at the earth's surface will retard the forward movement of the wind. But what prevents as great a velocity of wind above this maximum zone as the wind slides down the gradient? Again, this zone of maximum velocity is not always present. Sometimes, and this is usually in the early morning, the kite shows its presence during the ascent, and its absence during the descent. Occasionally the phenomenon is reversed, or even does not show at all.

As to the *direction* of the winds, a few figures are of interest. Southerly winds have prevailed in 80 per cent of the ascensions, and westerlies in 57 per cent. This gives more than 100 per cent because the southwest winds are counted as both southerly and westerly. Apparently these southwest winds are passing down the gradients into the areas of low barometer which are continually passing over the Great Lakes eastward down the St. Lawrence Valley in the usual form of the cyclonic whirl. Oftentimes the anticyclonic areas, with light winds, will remain for an extended period in one vicinity, thereby preventing a kite ascension. Cool, cloudy days are likely to prevent kite ascensions. The clouds will show a rapid movement, but the vertical convectional currents are so slight, due to the presence of the cloud cover, that only occasionally is the wind strong enough to lift the kite. At this station, it is not often that the surface wind varies, in any direction, to any considerable extent from that above. On one occasion, however, the surface wind was northeast and the kite was in a south wind at an elevation of 3,500 feet. This ascension also displayed a very singular phenomenon which, while not meteorological, was of peculiar interest. On reeling the kite in, at intervals of a few feet on the wire, spider webs were found, and in some cases on the webs were very small spiders. While the kite line was extending to windward, one could see the webs hanging therefrom like a fringe. As the webs extended the full length of the line, they must have been borne as well in the northeast surface wind as in the south wind 3,000 feet up. The sky at the time was cloudy. No webs were found on the kite, and none were seen caught on the grass, trees or bushes. Perhaps these facts will interest entomologists.

When an ascension is made within an area of low barometer the humidity is usually recorded high, and the lowest humidities are recorded during a high barometer. The aerial humidity preceding rain has invariably been high.

Frequently an early morning ascension shows an inverted gradient of temperature. That is, up to 900 feet or 1,500 feet perhaps, the temperature rises higher than at the earth's surface, and then above

that height commences to fall again. As the sun rises higher and convectional currents move upward and downward this inversion ceases, as shown on the descent of the kite. Toward the middle of the afternoon the normal gradient is shown by an ascent, but if the descent is made during, or especially after, the twilight period then an inversion of the gradient is shown.

The electricity which ever descends the wire is strangely interesting. Sometimes five hours after thunder has been heard and the kite is 4,500 feet up, with cloudy sky, there will not be the least sign of electricity, and at another time, with the kite 1,000 feet high, and the sky nearly or wholly clear, the shock from the wire is far too unpleasant to take. Perhaps my opinion on electric shocks is not impartial. Those who saw the article in the Monthly Weather Review for April, 1898, will perhaps remember the accidents caused by electricity heating and burning the kite wire. It is about one of these accidents I wish now to speak. There seemed, on May 31, 1898, to be a thunderstorm approaching; no lightning was visible or thunder audible, yet my reeler and I commenced to pull in the kite. When the kite was still 3,000 feet up, at the end of 5,000 feet of wire, a bolt from the clouds was seen, by others, to hit the kite. We stopped reeling; we had to. I have been nearly in front of a 6-inch naval rifle at its discharge, and its noise was very mild compared to the report which we heard at the reel. We were stunned for a brief period and the wire was ruined by the discharge. Fortunately, the kite reeler was wearing rubber overshoes, but I was not, and in consequence got a burn on the sole of my foot; this, however, was of small import in view of the experience gained. The kite fell 3,000 feet, breaking one stick. Several really ludicrous events have occurred when the kite has behaved badly. Sometimes the operators get knocked down and dragged about by the kite in attempting to land it, while the urchins, at a distance, shout humiliating taunts.

It would appear, however, that the aerial observations are not, as a whole, of continuous value, because of their great irregularity. It is not often that the kites go up at 8:00 a. m., and then it is less often that synchronous observations can be made at each of the kite stations because of atmospheric conditions. One requisite is some more sensitive form of kite meteorograph; another is some form of captive balloon that can ascend when rain or lack of wind prevents the kite from going up; but, with the appliances available, it is certainly a most creditable accomplishment for the Weather Bureau to have made as much as it has out of the aerial investigation of the free air.

Mr. Piercy. My duties in connection with aerial observations at North Platte, Nebr., have only been of a cursory nature, but my interest in the work has prompted me give it some study. The practical work is performed by an aerial observer, so I can only deal with this subject in a general way. Aerial observations were first begun at North Platte, in April, 1898, and have continued ever since. By careful observance I have noticed that an unusual amount of humidity, electricity, and moderately low temperature in the upper air strata frequently indicate precipitation within the next twenty-four to thirty-six hours. An absence of these conditions foretells dry and fair weather.

A high temperature in the upper atmosphere is invariably the forerunner of a warm wave on the earth's surface, which usually occurs within twenty-four hour. While I have had no experience in aerial work during the winter season, I believe that it will be of value in forecasting cold waves.

TOPIC No. 17.—SHOULD NOT A BOOK PROVIDING FOR A PERMANENT RECORD OF METEOROLOGICAL OBSERVATIONS FOR A PROLONGED PERIOD BE FURNISHED TO THE SECTION CENTERS FOR THEIR USE AND FOR VOLUNTARY STATIONS?

G. A. Loveland, Lincoln, Nebr., and J. W. Bauer, Columbia, S. C.

Mr. Loveland. The need of some method of filing, in compact form, at the section center, the monthly values of the more important meteorological data recorded by the voluntary observers has been felt in Nebraska for a long time. The records can not be used in a study of the climatology of the State to the best advantage, if at all, until all the record of each station has been collected in such manner that it can be viewed as a whole and the essential facts obtained quickly and easily.

To answer the many questions constantly being asked this office regarding both the climatology and the weather during specific periods of the past in various parts of the State, it was found early in the history of this work in Nebraska to be a saving of time to thus arrange data. It seems to me there can be no question as to the advisability of some method of arranging the records by stations; it is an absolute necessity. The only questions it seems to me are: What is the best method, and what data should be entered? Two methods have been tried in Nebraska and each had its disadvantages. One is placing the record in a large unwieldy book; the other, placing each element, as temperature or precipitation for each station for the use of the station on a loose sheet of paper, and then arranging these sheets on a file in the alphabetical order of the stations. I am inclined to prefer the separate sheets, but think a thin cardboard should be used as the paper becomes torn and wears out so easily.

The cards could be printed alike for all the elements, and the nature of the data entered at the top of each card when the data was entered. Holes should be punched on the side for filing, and the cards could then be turned like the leaves of a book. A file case should be furnished to protect the cards like the covers of a book. The great advantage of this system is that the order of arrangement of the stations can be changed at will without trouble or delay. If the records of a district or a few stations are being studied they can be separated from the rest of the file to a great advantage in the work as well as a saving of time.

The data to be entered would depend largely upon the location of the section and the use made of the records, and somewhat upon the force at the section center available to do the clerical work required to keep the records copied. With the card system the amount of data thus kept tabulated could be left to the director of the section. I should not think it desirable to enter daily records at all but only monthly values.

The cards would be used to supplement the regular monthly report

and not to take its place, and one set of these cards should be furinshed to each voluntary observer.

Mr. Bauer. The question presupposes a doubt as to the suitability of the present Form No. 1009—Met'l for purposes of a permanent record. Form No. 1009—Met'l is well devised for transmitting to the section centers and to the Central Office the reports of voluntary observers, but owing to the flimsiness of the paper and the fact that the leaves for each month are necessarily loose and separate, the form is not suitable for permanent record, either at the section center or at the home of the voluntary observer, few of whom are equipped with desk room for filing such papers, or even the crudest facilities for binding them in annual volumes, and hence their liability to be lost or inadvertently destroyed. A suitably arranged book would avoid this, and by showing the voluntary observers that their reports are deemed of sufficient importance to be preserved in permanent form, would encourage accuracy and the continuity of their records.

Such a book, strongly bound, should provide space for notes on the more important meteorological events that are but inadequately described by figures alone; the spaces for the tabular data should be so arranged as to afford facilities for easy comparison by months; when the book is filled, the means of the footings would represent average conditions. By such an arrangement, a comparatively small book could be made to serve for many years.

It might be well to have a separate book for each station for the use of the section center, but this could be made much smaller by omitting all blank spaces for remarks, etc. It is true, that to keep such a book for each voluntary observing station at the section center would involve much additional labor in copying, but the results would, in my opinion, justify the additional time and labor required.

This office has recently been requested by several voluntary observers to supply missing reports which had been mislaid or lost. Such requests have a twofold signification: First, that voluntary observers are desirous of having a complete record of their observations, and second, the unfitness of the present Form No. 1009 for purposes of a permanent record on account of liability to be lost.

Without hesitation or doubt, I therefore declare myself heartily in favor of providing books in duplicate, one copy for the section center and the other to be issued to voluntary observers as their private property, for permanent record of voluntary observer's meteorological observations.

Mr. Linney. A brief inspection of the sample book for a permanent record of the voluntary observations, exhibited by Mr. James Berry, Chief of the Climate and Crop Division, would lead me to state that it might be an excellent thing for issue to such of our voluntary observers as desire something for permanent record purposes, but I would suggest that it should not be made requisite to the establishment or continuance of, any voluntary station, nor should it be considered a part of the equipment of all stations. It should be borne in mind that in the hands of the average voluntary observer the use of such a book will cause many faults to arise. Thus, if the book is made the permanent and original record many errors will

creep in by copying to the Forms No. 1009, and much delay will be sure to result in forwarding forms. With probably 80 per cent of the observers many errors will regularly be made in attempting to find sums, means, highest, lowest, etc., and the number of errors which will thus arise, making correction necessary, will seriously impair the value and appearance of the book as a permanent record in the hands of the voluntary observer.

As to its usefulness, or value, at the section center I can not assent for several reasons:

First. It is wholly impracticable for the directors, with the present office help, to attempt to make the copies required, and even if the necessary help were provided the results would not justify the outlay of time, money, or effort, for once you have the copy in the book you have nothing more than you had on the tissue Form No. 1009, and it is not original.

Second. The present plan of tissue duplicates furnishes an accurate and good permanent record, easy to handle, compact, and, if properly filed, accessible, while they only require computation and summarizing to be available for current and future use.

Third. The monthly publication of each section summarizes the reports of the section as a whole and individually, thus covering all of the ground given in the proposed book, and these, if bound in yearly or bi-yearly volumes, would become a neat and valuable permanent record to supplement the retained Forms No. 1009.

Fourth (by way of suggestion and recommendation). A file case somewhat after the plan of that in use at the Chicago office, a box being provided for each county in the section, would cost but little more than the proposed books, which must be specially made, and the reports could then be filed easily and safely, and for future use would be at hand at any moment.

Mr. Palmer. Relative to the book for permanent record of voluntary observer's report, spoken of and shown at Omaha, I have the honor to make the following report:

Many voluntary observers would undoubtedly like such a book, and it would be advisable to place one at their disposal. Most of them, I believe, find their tissue reports, properly filed away with the section publications, sufficient for their use.

A proper file case for filing all reports from each station together seems to me much preferable to the book shown. In this way records from each station can be readily referred to. The copying of these monthly reports, especially the maximum and minimum temperatures and the daily rainfall, means a large amount of additional labor at the section centers.

I believe that the page in the book devoted to the general summary should be issued for the section centers, but in a slightly different form, ruled so as to have room for "sums to include" and "means to include" succeeding years. Then the section centers could keep all means for substations up to date, and also furnish material for the "climatological addenda" such as is published by the Ohio and Indiana sections.

I have been working up the records at my substations, including only temperature and precipitation, and I should have been glad to have had blanks, as mentioned above, for this work.

TOPIC No. 18.—PAPER: ATMOSPHERIC MOISTURE AND ARTIFICIAL HEATING.

W. M. Wilson, Milwaukee, Wis.

Mr. Wilson. The importance of aqueous vapor as a constituent of our atmosphere was not exaggerated by Tyndall, when he startled the scientific world by the announcement that "The removal, for a single summer night, of the aqueous vapor from the atmosphere which covers England would be attended by the destruction of every plant which a freezing temperature could kill."

For a long time humidity, relative or absolute, has taken its proper place among the principal meteorological elements, and every meteorological service in the world maintains a series of observations of atmospheric moisture with the same care as that bestowed upon temperatures, barometric pressure, or rainfall. The intimate relation existing between the aqueous vapor of the atmosphere and its precipitation in the form of rain or snow has inspired practical meteorologists with the hope that in the study of this element might be found the solution of the problem of rainfall, and possibly lead to more accurate results in forecasting its occurrence. But while the relation existing between the various forms of water is very close, a knowledge of the exact conditions which exist, in sufficient force to account for a downpour of rain, has eluded our grasp, and the results of the study of this element, so far as practical weather forecasts are concerned, have been principally negative.

From a medical point of view, however, the importance of the relative evaporative power of the atmosphere, in estimating the peculiarities of special climates and their effects upon the human organism, must be evident to all who are familiar with the physiological functions of the skin and lungs, and of the mucous membranes of the entire respiratory tract. Indeed, according to Dr. Albert Buck:

> For certain classes of invalids the prevailing humidity at a given place is a matter of more consequence than the temperature; more important than the mean temperature—nay, in the opinion of some authorities, a matter of more import than is the variability of temperature, be the variations of the latter never so frequent, never so great, and never so sudden and sharp in their onset.

The connection which subsists between the humidity of the atmosphere and its capacity for absorbing moisture from bodies, both animate and inanimate, with which it is in contact, is a connection of the closest possible description, but it is a deplorable fact that medical literature is almost entirely lacking in a scientific explanation of the effect of the different degrees of humidity upon the animal economy. There is abundance of empirical evidence of the efficacy of the conditions prevailing in the different portions of the world for the cure of catarrhal and pulmonary troubles, but whether the improvement which not infrequently follows a residence in Colorado or New Mexico is to be accounted for by the dryness of the climate, as is the popular impression, the elevation above sea level, the abundant sunshine, the new surroundings, or the outdoor life, or whether it is the result of a combination of all, physicians are unable to say with any degree of certainty. It is, however, generally admitted that while aridity and elevation may play an important part in the curative process, the efficiency of the climate in this respect does not depend on these elements alone, as equally good results are obtained from a residence at Torquay or Falmouth, on the south of England, which are

among the most humid climates on the globe, and are elevated only a few feet above the level of the sea. Many believe that the results, so far as humidity is involved, which follow a residence at any place possessing special climatic conditions are not so much due to the dryness or saturation of the atmosphere as to the comparative freedom from sudden or extreme changes in humidity, incident either to the natural climate or to the comparatively small range between the humidity prevailing inside the dwellings and that of the outside air.

We will assume that during the winter months the normal relative humidity over the more populous portions of the United States, especially east of the Missouri and north of the Ohio rivers, is 72 per cent, and that the average diurnal range is from 60 per cent to 85 per cent, which, it is believed, fairly represents the conditions prevailing over the area named.

For the purpose of obtaining data upon which to base a comparison between the average external humidity and the prevailing conditions with respect to moisture found in business offices and living rooms, observations were carried on during the past winter in buildings heated by steam, hot water, and hot air, and it was found that the average relative humidity from steam and hot water heating, with an average air temperature of 72°, was 28 per cent, while from furnace heating it was as low as 24 per cent. Dr. Albert Barnes, of Boston, found that the relative humidity in his office building, with an air temperature of 72° was 31 per cent, while Mr. Henry, in investigating the relative humidity in the Weather Bureau building at Washington, during March, 1896, found that, with an air temperature of 72°, the relative humidity was 32 per cent. From these observations, it is safe to assume that the average relative humidity in dwellings and offices, during that portion of the year which requires artificial heating, is about 30 per cent, or about 42 per cent less than the average outside humidity and drier than the driest climate known.

The evaporative power of the air at a relative humidity of 30 per cent is very great, and when the tissues and delicate membranes of the respiratory tract are subjected to this drying process, a corresponding increase of work is placed upon the mucous glands in order to keep the membranes in proper physiological condition, so that Nature, in her effort to compensate for the lack of moisture in the air, is obliged to increase the functional activity of the glands, and this increase of activity and the frequent unnatural stimulation, induced by the changing conditions of humidity from the moisture-laden air outside to the arid atmosphere within our dwellings, finally results in an enlargement of the gland tissues, on the same principle that constant exercise increases the size of any part of the animal organism. Not only do the glands become enlarged, but the membrane itself becomes thickened and harsh, and, sooner or later, the surface is prepared for the reception of the germs of disease which tend to develop under exposure to the constantly changing percentage of humidity.

If the limitations of this paper allowed, it might be interesting to notice some remarkable cases which have come under observation where catarrhal troubles have been relieved and apparently cured by simply introducing sufficient moisture into the air to bring the conditions to something near the normal.

The economic side of the question is equally interesting, and has

the special attraction of being more nearly capable of a mathematical demonstration. In a room in which the temperature is 72°, with a relative humidity of 30 per cent, the temperature of the wet bulb is 54.5°. If a room with a sensible temperature of 54.5° is considered comfortable—and there is abundance of evidence to show that the wet-bulb thermometer does not vary greatly from the sensible temperature under ordinary conditions—the same result can be attained by heating to only 60° and supplying sufficient moisture to raise the humidity to 70 per cent, which still conforms very closely to the normal condition of the outside air, so far as moisture is concerned. It would probably be impracticable to maintain uniformly a relative humidity of 70 per cent, especially with a low outside temperature, as the condensation upon the windows would be undesirable; but by heating to 65° the relative humidity could be held at 50 per cent without any ill effects, except possibly on extremely cold days.

While no very accurate information is at hand as to the cost of heating at different temperatures, competent engineers estimate that about 25 per cent of the cost of heating is expended in raising the temperature from 60° to 70°. If this be correct—and it is the best information obtainable at the present time—one-fourth of the cost of heating could be saved by holding the temperature at 60° and raising the humidity to 70 per cent, still maintaining a wet-bulb temperature of 54.5°, the same as that obtained by heating to 72° under ordinary conditions. But to be conservative and avoid the possibility of any unpleasant results from condensation, our dwellings could be heated to 65° with a relative humidity of 50 per cent, and still save 12½ per cent over the present cost. A practical test was made on a small scale during the past winter with a view to determining a comfortable sensible temperature and the possibility of maintaining the humidity at a constant percentage. A valve controlled by an electric current was attached to a steam radiator and and the electric contact made through an ordinary hair hygrometer. By this means it was possible to steadily maintain the relative humidity at any point desired, but owing to lack of means of controlling the temperature, the experiment fell short of determining the exact temperature and humidity at which the most comfortable conditions prevailed. The recognition of the need of a larger quantity of moisture in dwellings heated by artificial means is not new, but the mechanical difficulties encountered in automatically introducing the moisture in sufficient quantities to accomplish the desired result, or of controlling the amount introduced, has largely deterred practical research in this direction. But it is hoped that these difficulties will be overcome, and at no distant day a humidifier will be as necessary an adjunct to every first-class heating plant as a temperature regulator is at the pretent time.

TOPIC No. 19.—SHOULD NOT A BOOK BE PROVIDED SUITABLE FOR KEEPING RECORD OF THE ISSUE OF INSTRUMENTS AND FLAGS TO VOLUNTARY OBSERVERS?

R. G. Allen, Ithaca, N. Y., and B. H. Bronson, Bismarck, N. Dak.

Mr. Allen. In answer to this question I would say that such a book would be very useful and of much benefit in keeping a correct and

easily accessible record of instruments and flags loaned to voluntary observers, but, in my opinion, a card record would better serve the purposes, would always present a neater appearance, and would be more satisfactory than the book record. This card system would require for each substation a small sized card, with a suitable heading showing blank spaces for the name of station, name of observer, date of establishment, latitude, longitude, and elevation. Just below this heading I would suggest that spaces be provided for the different instruments usually furnished voluntary stations and also the different kinds of flags. With this card method, when a station is discontinued, the card for that station should be removed from the file. When a station is established a card showing the name and equipment could be placed in its alphabetical order. This method would insure a neat, easily accessible, and satisfactory record.

In using a bound book more or less changing is necessary when a station is discontinued or an instrument broken or returned for any cause, and this detracts from the neatness of the record.

I have no doubt but that a book for keeping record of instruments and flags will be valuable and convenient but in my opinion the card record more so.

Mr. Bronson. Mr. Chairman, in my opinion such a book should be provided. I have kept one, showing kind and the number of all instruments received and issued to voluntary observers, for the past five years, and have found it very convenient.

TOPIC No. 20.—ARE CHANGES IN THE PRESENT FORMS (1053 AND 1054) FOR REPORTING WEEKLY CLIMATE AND CROP CONDITIONS ADVISABLE?

Charles E. Linney, Chicago, Ill., and A. J. Mitchell, Jacksonville, Fla.

Mr. Linney. I find very little use for the special report card (Form No. 1054), because my observers and correspondents are usually in advance of requests for matter. The large number which I have makes it possible for me to get from the cards of any week more information than I can possibly use, and generally in advance of the time when it is really pertinent information; thus the possibility of the first frost in the fall is usually anticipated from one to two weeks before the usual request from Washington; so with other things; and I therefore find very little use for the form. It is all right, however, when occasions arise for its use, and in its present form answers every purpose.

Mr. Mitchell. At the Indianapolis Convention I suggested the propriety of making Form No. 1053 conform to the size of the ordinary postal card, the object of the change being to reduce the possibility of mutilation which frequently occurs in transit. With the reduced size the card will be of ample dimensions to contain all necessary facts regarding condition of crops and effect of weather on same. In fact, the change would emphasize the necessity for succinct statements and brevity by crop correspondents, which count for a great deal in compiling a summary for the State. So far as the Florida section is concerned, Form No. 1054 answers all requirements.

TOPIC No. 21.—SHOULD COMPENSATION BE ALLOWED PERSONS, NOT IN THE EMPLOY OF THE BUREAU, WHILE LEARNING STATION DUTIES TO ENABLE THEM TO PROPERLY PERFORM SUCH DUTIES IN CASES OF EMERGENCY?

DAVID CUTHBERTSON, Buffalo, N. Y., and G. E. FRANKLIN, Los Angeles, Cal.

MR. CUTHBERTSON. The Weather Bureau of the United States Government was organized to meet the unforeseen; it has always aimed to be prepared for any emergency in order to prevent the interruption of its work in any of its branches, since otherwise irreparable loss to many communities may result.

One of the principal things to be provided for is the proper performance of station duties when we have left but one or two men at a station. To enable us, therefore, to be in readiness to meet any crisis, and keep the work going on with regularity, the question has arisen, whether we shall compensate the substitute while he is being instructed in station duties so as to be ready to act in the event of an emergency? As we are willing to pay for the work when the emergency arises, I contend that by all means it is the part of the Government to allow reasonable compensation to a competent person while under instruction.

In my opinion a young man attending a high or normal school or college could be instructed during the afternoons of school days, and on Saturdays could be given practical work on routine duties of a station. This would not interfere with his scholastic duties, and, being an attendant at school or college, having no other remunerative position, he could always be relied upon to render his services as soon as required; when he leaves school and enters his regular vocation then another such young man could take his place.

I am thoroughly convinced that as we expect the person to fill an emergency he should be suitably paid for the time he devotes to the Government in order to learn his prospective duties. At large stations, such as Buffalo, an emergency can not well occur without being successfully met, as the important duties of an observer can always be taken up by the map distributor, and the latter's duties performed by a hired messenger.

MR. FRANKLIN. It is well recognized that at a one-man station it is necessary to have an experienced person to continue the work, at least the meteorlogical portion, in order to maintain the continuity of the records in case of the unavoidable absence or the disability of the official in charge.

While the regulations of the Service direct that provision should be made to obtain the services of some one for such cases, yet at present no compensation is allowed for training a man for the duties expected of him, and the difficulty of obtaining some one who is willing, without remuneration, to spend time learning station work, with a remote possibility of employment, will, I think, be well recognized by those who have had experience in the matter.

There are stations where it is possible to secure the services of an ex-official of the Bureau, or those of a voluntary observer who is sufficiently familiar with station work to assume charge in emergency cases. This, I think, is an exception and not the rule, so it will be found necessary to train some one as an emergency assistant.

It requires time and experience to obtain the knowledge necessary

to perform the various duties of a Weather Bureau office, and while there may be young men who would give their time and attention to obtain such knowledge without a desire for compensation, such instances have not come to the writer's attention; on the contrary, compensation has been expected, because it has been found necessary to spend considerable time at the station, which otherwise would be given to some line of business that afforded a pecuniary return. Moreover, those who are obtained for such emergency services are usually persons of limited means who can ill afford to give the Government gratuitous service in learning prospective duties.

It is, therefore, the opinion of the writer that some system of remunerating emergency men while under instruction could be adopted with benefit to the service. A well informed man would then be at hand when required, and the station work would be continued without break or lapse, particularly in the meteorological portion.

Mr. Townsend of Philadelphia was given the floor to explain his self-registering rain gauge. The chair appointed, as a committee to confer with Mr. Townsend and report upon the gauge, Messrs. McGann, Walz, and J. W. Smith, of Boston.

Mr. Sims obtained permission to exhibit a simple frame for use in furnishing advance information. The chair appointed as committee to examine and report on the apparatus, Messrs. Townsend, Loveland, and Outram.

Mr. Bate moved—

That the Convention of Weather Bureau Officials tender their especial and grateful acknowledgments to the Commercial Club of Omaha for the hospitable courtesies they have so generously extended in placing their elegant and commodious rooms at the disposal of the Convention for its sessions.

This was adopted, and the Secretary directed to send a copy to the Commercial Club.

Mr. McGann moved—

That the thanks of this Convention be extended to Mr. James Berry, Dr. Cline, and the other members of the reception committee for the very excellent arrangements made for us during this Convention.

Seconded, and unanimously adopted.

Professor Hazen moved—

That it is the sense of this meeting that we have profited greatly by this Convention and that it would be a good thing for us to meet annually.

Mr. Hammon agreed heartily with the first part of this resolution. He pointed out, however, that the expense of a trip from the Pacific coast was too great to allow of attending conventions oftener than once in three to five years. He thought Congress would look upon it as a reasonable thing to pay part of the expense of one of these conventions.

Professor Moore said he would ask from Congress authority and an appropriation to pay part of the expenses of the Convention.

Professor Hazen's motion was adopted.

Some expression of opinion arose as to the time and place of the next meeting.

Mr. Pindell and Mr. Bate spoke for Chattanooga, Tenn.; Mr. Hammon, for San Francisco, Cal.; Mr. Pague, for Portland, Oreg.; Mr. Cline, for Galveston, Tex.; Mr. Conger, for Detroit, Mich.; and Mr. Mitchell, for Jacksonville, Fla. No vote was taken, and this matter is entirely in the hands of the Chief of the Weather Bureau.

Professor Moore. It is a matter for congratulation that we have had the advantages of this Convention and of the enjoyable, sociable time of last night [referring to a banquet attended by the members of the Convention and their guests]. The utmost decorum has been manifested by all present. We enjoyed ourselves, we had our fun, but we were temperate, and no man lost sight of the fact that he was a gentleman. It is a source of congratulation that this was the case. Now, it is probable that the presiding officer derives more benefit from such a convention as this than the individual members. He gets here what he could not get by many years of official correspondence—that close touch and affinity with the officials cooperating with him in this great institution that enables him to act intelligently and for the best interests of the public service. I feel, as I go away from here to-day, that I have acquired a fund of information from the very best sources that will aid me and guide me during the next year or two in my executive functions at Washington.

Furthermore, this Convention has enabled many deserving men in the service to come forward and present papers to show what they can do. It is a sort of forum in which they can be heard, and it is of great assistance to the head of the Bureau to be able here to see and meet with these workers, that when it comes to the selection, which is vested in him, of officers to go forward to higher stations, the associations here formed and the opportunities for judging of the capacity and merits of our officials are sure to be of great assistance and render him less liable to err.

Gentlemen, this meeting is adjourned.

As previously stated, it was not possible to read in full before the Convention many of the papers contained in the program, among which are those given in the following appendix.

APPENDIX.

PROFESSOR MARVIN'S WEIGHING RAIN AND SNOW GAUGE.

W. W. Carlisle, Minneapolis, Minn.

The city engineer of Minneapolis, desiring to ascertain the rate of excessive rainfall, expecting to use the data in determining the proper sewer capacity to be allowed in the estimates for sewer construction for the different sections of the city, purchased one of Professor Marvin's weighing rain and snow gauges. After the instrument had been given a reasonable trial, the chief engineer of the sewer department declared himself unsatisfied with its record. Having obtained control of the gauge I have made a careful study of its mechanism, thoroughly investigating it in detail, perfecting its arrangement and removing its defects whenever, by experiment or by observations of its behavior during storms, they were made apparent. I have finally succeeded in making it very reliable, and by introducing into its electrical circuit an instrument which I have called a "controller," it is compelled to produce a record which shows faithfully every increase or decrease of the rate of fall and to register within four seconds of the exact time when the first thousandth of an inch fell into the receiver, with the same degree of accuracy for every succeeding thousandth, including the last. It will register snow equally as well as rain while the wind, formerly so troublesome, makes absolutely no impression whatever upon the record.

While the instrument, at least the one furnished this city, embodies most of the essentials of a perfect mechanism, yet some details of the design seem not to have been fully carried out by the maker, leaving the instrument in an unfinished condition fatal to perfect action. In delicate instruments, and particularly electrical devices intended for outdoor use, every detail must be looked into and every safeguard thrown around it. An imperfect machine naturally must be unreliable and inaccurate.

The scales of the gauge are protected by a hood manufactured from sheet iron, with a hole roughly cut in one side, which is closed by a door also constructed of sheet iron. It is obvious that a sheet iron door, closed against a frame of the same material, can not be shut air tight or even close enough to keep out the rain. The hood has a rectangular base, that shape being retained by means of a wire placed in the hood in a manner identical with the way in which a tinner finishes the top of a tin pail. It is, of course, physically impossible for the base so constructed to fit closely to the bed. In fact it fits so loosely that during a winter storm the snow would blow inside in such quantities as to completely cover up the scales and permanently stop all action. The hood is fastened to its bed by ordinary hooks and eyes.

The gauge is essentially a storm machine, the first requisite of which must be the complete protection of its internal machinery from water and air currents, either of which will operate against its

normal action and ultimately destroy the value of the record. Even if the base is reasonably water tight, but will admit a current of air, dust will be deposited on the machine, interfering with free action and increasing the resistance of the electrical contacts. In damp weather the scales will sweat, while the steel of the scale bearings will oxidize in almost any kind of weather if exposed to a free circulation of air.

To remedy the evil, I fitted the bed with strips of heavy rubber and placed a piece of thick felt around the door. This answers the purpose fairly well, but the sheet iron hood should be firmly soldered or riveted to a frame of heavy metal cast and ground to accurately fit the bed. Instead of being loosely fastened by hooks and eyes, the hood ought to be firmly bolted to the bed to make the joint as tight as possible. It need never be taken off except in case of accident to the gauge. The door should be made of cast iron ground to fit a frame of the same metal. In short, the hood should be made by a machinist and not so much after the fashion of a tinsmith. One piece of the working mechanism of the scales passes down through the bed and becomes thickly covered with rust and smoke and, from the nature of its exposure, can not be kept clean. It also requires a hole in the bed plate which is large enough to admit a considerable current of air. A small iron box might be fitted over this, a detail which would contribute appreciably to the preservation of the delicacy of the instrument. The top of the copper can, for holding the rainfall, is so flexible that it can easily be bent between the thumb and finger in the ordinary handling of it, making it extremely liable to get out of a true circle and rub against the sides of the hood. This might be remedied by fitting a thin brass ring around the top. The can itself rests loosely on the scale beam and it is never absolutely certain that it is in the center so that it will not touch the cap which fits over it. To remove this uncertainty a small steel point might be soldered on the bottom of the can, in the center, to fit into a hole in the scale beam, always assuring a proper position for the can. This little detail would save a great deal of inconvenience and uncertainty and, occasionally, a record.

The dasher, fitting into a cup of glycerine, is fastened to the scale beam by a rather awkward clutch with no arrangement to keep the dasher in line with the cup. If the clutch is to be used, some means should be found to insure perfect and permanent alignment. The dasher itself is, however, a makeshift to correct an evil which it does not correct, and since attaching the controller I have dispensed with the dasher as useless. The machine was wired from binding posts on the register to a set of binding posts on the gauge bed, thence to a set of binding posts on the frame, thence to the contact points, the whole forming a somewhat high resistance. The under surface of the bed soon rusted badly, covering the insulation of the binding posts with fine rust, which may not affect the insulation in dry weather, but when the rain drops spatter up underneath the wet rust makes a good path for the current, so that the instrument is short circuited and the record ceases.

In order to effectually prevent this I removed the wires from the binding posts, ran them directly, and soldered them to the wires running to the contacts and the gauge magnet, lessening the resistance and the liability to leak.

These changes render the instrument thoroughly storm proof, and reliable action is now the rule and not the exception. However, with these minor details carefully adjusted and reliable electrical action secured, there still remains a grievous fault which renders the record useless in point of time and amount. The gauge is practically like a steam engine without a governor.

In theory the scales are in constant equilibrium, or at least always sensitive to about 11 grains or 0.001 of an inch of water; immediately upon receiving a deposit of that amount the beam settles to the contact point and the register pen instantly makes its mark, leaving a reasonable inference that, as only such a small amount of water has fallen, the storm began a very short time before the mark was recorded. After the first movement the instrument is in readiness to record the next 0.001, and so on. On account of the interference of the wind, in actual practice this theory is far from being realized. With the funnel removed, which is necessary during the snow season, and, therefore, for at least half of the year in this latitude, the scales will be persistently out of balance from 0.01 to 0.03, depending upon the pressure of the wind.

Now, suppose the scales were balanced immediately before a fall of rain which began at 1 a. m. and ended at 1:30 a. m., amount 0.04. At 1:30 a. m. the wind increased and agitated the scales until they were off the balance 0.03 at 1:50 a. m., adding that much to the record, making a total of 0.07 on the sheet. How can it be told positively from the record that it actually ceased raining at 1:30 a. m. and not at 1:50 a. m. as shown on the sheet? How can it be determined whether the extra 0.03 should be taken from the end of the record or from some other portion? Take another case: It begins to snow during the night, the register making its first mark at 1:10 a. m., with the scales known to have been previously blown out of balance 0.02. As snow frequently falls in fine dry flakes at rates which often amount to much less than a 0.01 per hour, how will it be possible to tell from the record the commencement of the storm within several hours? Supposing the storm ceased at the time the machine recorded its first 0.001 and at the end of an hour the wind increased, blowing the scales off 0.03. The evidence on the sheet would tend to prove that the snowstorm occurred as a heavy fall of snow of short duration at about 2:10 a. m. The exact time and rate of fall during a storm are often far more important questions than the total amount of precipitation. On the 27th of last March, rain began to fall at 11:55 a. m., the controller had been placed in the circuit of the guage as an experiment. A thread holding up the armature was accidentally broken at six minutes after noon and was replaced at 12:37 p. m., during that interval the guage was free to work over its usual circuit, the funnel, on account of the liability of more snow, had been removed. An examination of this record shows that up to the time when the controller was cut out of the circuit, the precipitation was fairly regular at a rate of about 0.08 per hour; at this moment, the gauge, being suddenly placed at the mercy of the wind which was gusty, made a record of 0.02 at a rate of 0.50 per hour, or more than five times the actual rate. For a space of five minutes no record at all was made, apparently indicating that the storm had entirely ceased for that period. At 12:30 p. m. another record of 0.02 was marked on the sheet followed by a blank of seven minutes; at this point the

controller was again placed in the circuit and the true rate recorded, making a smooth continuous line. From personal observation, the rate of fall appeared to be steady. This proves that at no particular minute can it be determined from the record that rain or snow was falling, which to say the least is a very serious fault.

The so-called controller above mentioned was devised for the purpose of eliminating all effects of the wind and of continually maintaining the scales in equilibrium.

The mechanism of the instrument may be described as follows:

An electromagnet is fastened horizontally to a base. Its armature carries a lever which, when the armature is down, touches an adjustable contact, closing the circuits of the rain gauge, which are otherwise broken at this point. This magnet is placed in direct circuit with the scale contact, the sole duty of the scale contact being now to work the controller magnet and not to produce any action whatever in the gauge or register magnets. The wire from the gauge magnet is disconnected from the scale contact and led through the break on the register to the lever of the controller magnet. The battery wire leads up to the contact point underneath the arm. Above the controller magnet is a system of clockwork, the second hand of which is replaced by a toothed wheel which, of course, makes its revolution once every minute. The axis of this wheel carries a loose pulley. A thread attached below to the armature runs over the pulley carrying a small weight at its loose end. This weight, aided by the usual armature spring, maintains the armature at its highest point. The loose pulley also carries a catch which hangs underneath the minute wheel until the armature begins to descend, when the catch immediately hooks into the wheel, after which the movement of the armature is retarded and can descend only at the speed of the wheel. The time, therefore, which the armature will consume before it finally touches the contact point is governed by the clock.

This arrangement results in preventing the agitation of the scales by the wind from affecting the register, for as such movements are only momentary in character, they only suffice to move the controller magnet a fraction of its distance, while its full movement is necessary to bring about action in the gauge and register magnets. If, however, a permanent weight like rain or snow falls into the receiver, the controller armature settles firmly down upon its contact point, the gauge circuits are completed, and the proper record made. By experiment, I have determined that the scales are never held down by the wind for more than two seconds, and usually for only a small fraction of a second; therefore, I have set the controller magnet so as to allow the register to work every four seconds, or fifteen times a minute, sufficient to give a smooth trace for excessive rates. Thus, the gauge is always ready to record the first 0.001 which falls and gives the true amount at any time up to the last four seconds. The rain trace is, therefore, absolutely true to the fifteenth of a minute, and even that fraction can be eliminated by merely setting the clock ahead four seconds. The gauge scales being always as near equilibrium as its sensitiveness will permit, the knife edges are kept nicely polished, an important item in looking for the best results.

Drosometer.—The gauge scales are sensitive to about 11 grains; an ordinary pair of druggist's prescription scales are sensitive to a sixtieth of a grain. It is, therefore, possible to construct a much more

delicate instrument which will measure 0.0001 or less. With such an instrument, and with the controller included in the circuit, it is only necessary to expose, instead of the copper can, a device for dew, when a trace for that form of precipitation can be as easily recorded as for rain.

INTERCHANGE OF STANDARD CLIMATIC DATA.

ALEX. G. McADIE, New Orleans, La.

As a first premise let us agree that the climatic data of a State or section, as now published in the monthly bulletins, are of sufficient accuracy to warrant use in the scientific discussion of the many problems in agriculture, engineering, and hygiene, daily brought to the meteorologist for solution. If it be conceded that the material already available is of this character, a plea for the increase and diffusion of such matter needs but a presentation of suitable methods to be acceptable.

Doubtless every director realizes the necessity of keeping himself informed of the climatic conditions of other sections as well as his own. Especially must he follow the conditions of districts competing with his own in the markets of the nation. We are all aware how carefully reports of the yield of wheat in Russia, Argentina, and Australia are studied in the United States. The value of our own yield is largely dependent upon conditions existing elsewhere. What is true on the large scale, is true on the small one where different sections are concerned. The conditions in Kansas concern the grain grower in California and *vice versa.*

In the National Crop Bulletin, the information is available in convenient form each week of the growing season. So well is the work accomplished that suggestions for improvement are not easily made. Perhaps, those most interested, the farmers themselves, do not get the full benefit of the information. Possibly it may occur to some one present to suggest a remedy. We admit, though cheerfully, that little more can be desired with regard to the collection and dissemination of standard crop data during the season. The effect of climatic conditions upon crops, while easily chief among the interests of the community, is not the only matter of importance. Manufacturing and the mechanical arts have their place in a publication like the monthly bulletin, and their importance should not be underestimated. In all sections, there are constant calls for rain data from railroad engineers, from electrical engineers, and from mechanical engineers. These calls are now generally answered by letter containing the data desired. Could not such data be preserved permanently by publication and made to serve a larger clientele? Again, there is much scattered information in the possession of each section director which should be published. For example, the fact that magnificent crops can be grown on certain soils in California, with a rainfall which would be considered totally inadequate in many sections, is of interest to every farmer as illustrating the fact that amount of rainfall is not the only matter to be considered in connection with crop yield. The character of the soil, and the mechanical action in the soil, may be of almost equal importance with either the intensity or frequency of rain. Information of this character is just what intending settlers most wish

to know, and to give such information is a proper function of climate and crop work. In the Year Book of the Department for 1897 instances are given where certain crops are grown without irrigation. In southern California "Less than an inch of rain," says Whitney (p. 432), "falls on an average during the five months of the growing season from May to September."

Furthermore, an interchange of data between climate and crop sections, whenever abnormal or unseasonal conditions prevail, would be of value. Imagine a physician about to send a patient to a locality ordinarily well suited in the matter of climatic conditions to bring about recovery. If the patient is sent thither at a time when abnormal conditions prevail, he might experience the very conditions he desired to avoid. Such abnormal periods happen. In California the rainy season—the winter—was almost wholly without the usual rain in 1897–98, and the coldest weather known for years was experienced in some sections. If section directors were in a position to know where abnormal conditions are prevailing, physicians consulting them would certainly appreciate the importance of the information.

Finally, there is room in every bulletin for items of scientific interest. Many reprint short notes, extracts, etc., from the Monthly Weather Review. Could not some plan be devised whereby standard matter could be prepared, and, as in the syndicated articles of the daily press, illustrated, if necessary, and sent to the various sections? To make this more plain, imagine an article on frost, properly illustrated with half-tones showing effective smudging apparatus, frosted fruit, and the topography of frost belts. No individual director would care to stand the expense of the illustrations; but if made in quantity and distributed among twenty, each would cheerfully pay his small proportional share. Such a system would also encourage directors to bring forward papers showing peculiar climatic conditions in their respective sections.

Some one may say that work of the character described is now performed by the Monthly Weather Review. The answer to this is that the circulation of the Monthly Weather Review must of necessity by restricted to three or four thousand copies. The combined circulation of the monthly bulletins approximates twenty-five thousand and is constantly increasing. Furthermore, the readers of the Monthly Weather Review are different from the readers of the bulletins, and what is suited for one class is not for the other. The fields covered are not the same.

We conclude, then, that in the monthly bulletins we have the means for the successful dissemination of valuable climatic data. Can we, by cooperation, improve the good work now being done?

STUDIES OF CLIMATE.

F. J. Walz, Baltimore, Md.

It is very likely that during the course of the next few years the directors of the different climate and crop sections and State weather services will undertake the preparation of monographs or histories as a basis for studies of the climate of their respective sections or States. As far as I know, in one State only, has such a detailed climatic history been compiled and published up to the

present time. I refer to that comprehensive publication, the fourth biennial report of the Oregon weather bureau, prepared by Director B. S. Pague. It is well known that valuable articles of a special nature have been written by the directors of the climate and crop services of Texas, California, and other States; also that the Michifian State Board of Health has utilized meteorological reports in special studies, and that other scientific organizations have made special investigations based on Weather Bureau and State records. While recognizing the importance of these special papers, the fact remains that the Oregon report is probably the only sectional publication yet issued that enters fully into the subject of climate and meteorology in all its phases; in other words, it is the one report in which can be found not only a comprehensive climatic history of a State for the period of years covered by meteorological observations, but also a digested study of the conditions for all these years combined, together with a summarizing of the climatic features thus disclosed, and of the general laws that must determine, to a greater or less extent, the climatic history of the State in years to come; finally, and probably most important of all, the arrangement of the data contained in the report is such as to provide a ready basis for the preparation of special studies of any nature related to or dependent on meteorological or climatic conditions. It is this point in particular that I desire to bring to the attention of the Convention. It is understood, of course, that no reference is now being made to the weekly and monthly publications of the sections or States; their present methods of issue admirably serve as a concise record of current events, that being the purpose for which they are prepared. But in order, however, to serve wider and more general purposes, I am convinced that the great mass of climatic data now at hand, and constantly accumulating, requires still other forms of combination and arrangement to bring out valuable facts and laws now hidden; that is to say, it is as necessary to decide upon the best methods to be followed in compiling meteorological data as it is to collect the records themselves.

Imbued with this feeling, I have been led to the preparation of a model or outline of a satisfactory and uniform method of meteorological and climatic compilation, and which I will present for your consideration and discussion. This outline is somewhat on the lines that are being followed by the Maryland and Delaware Climate and Crop Service in a publication now in course of preparation. No originality is claimed for the plans set forth. I have simply adapted the methods found in various treatises to my ideas of the needs and demands of the respective sections in the prosecution of their labors.

As a prelude to the plan which follows, I wish to say that the words climate and meteorology have been used and considered throughout in their broadest significance, and not in the specific sense frequently employed by specialists in their several lines of investigation. Let us consider, for the present at least, the more general meanings of these terms, allowing the special relations of climate to soil, health, plant and animal life, etc., to be brought out later if desired, after the firm basis for these special investigations shall have been established by our primary efforts.

By climate, I mean the summing up and averaging of the meteor-

ological conditions of a section for a series of years, together with a determination and study of the average and extreme departures from these average conditions. A necessary condition in this connection is that the period covered by observations shall be sufficiently long to largely eliminate from the averages the excessive influence that might be exerted by the persistence of very abnormal meteorological features during one or more months, seasons, or years. A true climatic history can in this manner be obtained, and studies of the relations of the climate to human, animal, and plant life may then be intelligently carried on.

By meteorology, I mean the observation and study of the transient weather elements and phenomena as produced or controlled by the passage of cyclonic and anticyclonic areas and the attendant secondary disturbances, and an investigation of the characteristics of the more marked types of weather; that is to say, the determination and analysis of the weather elements resulting from the successive formation and movements of these areas.

Having thus expressed the limits within which I have thought it most desirable for our purpose to confine the meaning of the terms climate and meteorology, and with the understanding that it is within these limits that they have been considered in the preparation of the outline given herewith, I will submit the outline itself. I indulge in the hope that its discussion will bring forth valuable suggestions from the members present, many of whom, through long connection with the climate and crop work and an intimate acquaintance with all its needs, are doubtless better qualified than myself to deal with the problems considered in this paper.

OUTLINE FOR A UNIFORM METHOD OF METEOROLOGICAL AND CLIMATIC PUBLICATION FOR EACH SECTION.

INTRODUCTION.

Historical sketch and bibliography, embracing an account of the various meteorological records that have been obtained in the section or State, with the periods covered, and, where possible, the names of the observers. An account of the various stations that have been established. Also, of the publications of all kinds bearing upon the meteorology or climate of the section that may have been issued in or pertain to the section under discussion.

An enumeration and description of the various maps and charts that have been issued.

Establishment of and work done by organized meteorological and scientific bodies in the section, such as the National Weather Bureau, State Weather Services, local societies, etc.

INSTRUMENTS.

Descriptions and illustrations of the ordinary meteorological instruments, especially those in use in the regular Weather Bureau offices and by the voluntary observers.

METEOROLOGY OR WEATHER.

General description of the storm movements over the section: weather types and characteristics; general and local modifying influences; storm frequency and intensity.

CLIMATE.

(*a*) Geography, topography, and general physical features of the section under discussion; general geology; distribution and kinds of agricultural soils.

(*b*) Meteorological elements:

Temperature—

Mean daily (as far as possible).
Mean monthly.
Mean seasonal.
Mean yearly.
Average monthly and annual maxima.
Average monthly and annual minima.
Extreme temperatures, monthly and annual.
Amplitude or range; mean daily, monthly seasonal, and extremes.
Variability or average daily change for the single months; also, for the seasons and the whole year.
Temperature anomaly, or the average departure from the normal for the several months (and seasons) for a number of years.
Long period temperature oscillations.
Permanent increase or decrease in temperature.
Temperatures of evaporation, or wet bulb.
Number of days with temperature of freezing or below.
Number of days with temperature above 90°.
Number of days with mean temperature above 42°.
Advance of spring.
Average and extreme dates when ice forms in spring and autumn, and the number of days free from ice.
Frosts, average and extreme dates of first and last light and killing.
Relative frequency of cold waves in winter and hot waves in summer.
Influence of mountains, valleys, large bodies of water, etc., upon temperature.

PRECIPITATION.

Total amounts, monthly, seasonal, and annual.
Excessive amounts, and frequency of excessive rainfall.
Fluctuations in rainfall, monthly, seasonal, and annual.
Long period fluctuations.
Variability or departure from the normal.
Permanent increase or decrease in rainfall.
Average number of days with precipitation, monthly and annual.

If there is a pronounced rainy season, the percentage that the rainfall occurring in that season bears to the total for the year should be given.

The intensity of rainfall, or the ratio between the total amount and the number of days on which it fell.

Frequency or probability of rainfall, by months, seasons, and year.
Greatest number of consecutive days with appreciable rainfall.
Greatest number of consecutive days without appreciable rainfall.
Years of drought.
Destructive storms.

Thunderstorms, average number, and time and region of greatest frequency.
Influence of topography, bodies of water, etc., upon the rainfall.
Hail.
Snow.
Dew.

HUMIDITY.

Relative humidity.
Absolute humidity.

CLOUDINESS.

Number of clear, partly cloudy, and cloudy days, by months and for the year.
Sunshine.
Fog, number of days with.

WINDS.

Average velocity.
Prevailing direction.
Resultant winds.
Frequency, or average number of times the wind blows from each direction.
Months of maximum and minimum velocities of winds.
Highest velocity of winds.
Wind direction most likely to be followed by rain.
Wind direction least likely to be followed by rain.
Local winds, such as mountain and valley winds, land and sea breezes, etc.
Hot winds.
Cold winds.
Foehn winds.

CONCLUSION.

Summary of the principal features and main characteristics of the climate of the section as a whole, and of its several climatic divisions; also a table, or tables, showing a brief comparison of the climatic conditions of the section, or its divisions, with selected places in the United States and other parts of the globe.
Meteorological and climatic problems yet obscure or undetermined, and the best means for their solution, also the adaptation of current methods of work to that end.

VOLUNTARY STATIONS: THEIR OBJECT AND COLLATERAL FUNCTIONS.

A. J. Mitchell, Jacksonville, Fla.

All human enterprises at their inception are necessarily crude, and, possibly for this reason, it is but natural that they should awaken in the hearts and minds of some, a feeling of incredulity, but with passing time, and the increase of the knowledge begotten of experience, a progressive improvement is the certain result of a liberal and expansive policy. By way of preface, we feel that these remarks are not inapplicable to the Climate and Crop Division of the Weather Bureau, and while we would not detract one iota from the indisputable importance of other divisions, yet our position enables us to

speak with a riper knowledge of the duties in which we are immediately engaged. It is presumed that one of the primary objects in establishing voluntary meteorological stations was to collate data, and in the course of time, deduce reliable normals for future purposes. I believe it is conceded that it will require about forty years to deduce an absolutely correct normal—one that, in the general average, will compensate for all irregularities both of a plus and minus character. The utilization of climatic data progresses with the general mastery of reason and enlightenment over ignorance and indifference. There is scarcely an industry in any State which would not be more successfully operated by studying in advance the indispensable climatic elements, heat and moisture. The importance of success is such that the provident man can illy afford to take any risk. Closely pursuing every failure stalks the specter of poverty in old age, gaunt, repulsive, and hideous, yet, in many cases, a monument to man's lack of circumspection, and his failure to utilize the great facts made evident by the development of science.

That we may more forcibly illustrate our position let us take the industry of orange culture in northern and north-central Florida, and in approaching this subject we wish first to emphasize the fact that there is not a State in the Union possessed of such recuperative forces as Florida; although, almost in the lap of tropical verdure, and bordered on either side by the tepid waters of gulf and ocean, there is a limit to her greatness. We can not grow oranges successfully in the northern part of the State, nor will a residence in any portion thereof change the color of an aspiring black man to the shade of his white brother. However, it rains alike on the just and the unjust, and the tender plants of the Christian brother enjoy no special immunity from the uncharitable touch of winter's frost. In the absence of an established climatic record, emphasizing the possibility of recurring cold waves of sufficient severity to destroy the orange industry over northern portions of the State, many growers with commendable enterprise but faulty judgment failed to hearken to the suggestion of danger to the orange industry north of a certain parallel, and the result to many was not only failure to realize their expectations but a marked increase of liabilities over assets. Although adventurous orange growers may sometimes fail to give necessary attention to vital matters, we feel confident that none would have ignored established climatic statistics and recklessly undertaken to make orange culture a success within a sphere where freezes had been frequent and sufficiently severe to rob the enterprise of its remuneration. Here, then, we are able to appreciate the great importance of the records now being compiled by the various sections of the Weather Bureau. Before the days of agricultural chemistry, soil analyses were deemed an ephemeral myth. The ideal farmer was supposed to be that genus homo who, with more muscle than brain, was an adept at logrolling but knew nothing of the chemistry of the soil, but the advent of a few Secretaries of Agriculture of the type of the one now directing the affairs of the Department is rapidly emancipating agricultural classes from obsolete and profitless methods.

The question suggests itself then, if it be prudent to investigate soil properties before seeding, how much more important is the matter of seasonal and annual normals of temperature and rainfall. Chemistry can supply the deficiencies of the former, while irrigation,

a decidedly more expensive requisite, can alone obviate the latter. Less than a quarter of a century ago we knew nothing of the climatic conditions characterizing a large area of the Transmississippi country. A recognized authority had given the opinion and styled the section alluded to as an arid one, but later we find climatic statisticians demurring to such an opinion, and instead of there being an almost limitless waste of barren plains, it is found that the territory where rainfall is insufficient for agricultural purposes is indeed limited. Years ago the home seeker laid out his itinerary along certain parallels of latitude, and generally with no conception of the climatic conditions essential for the purpose and objects of his future vocation. His actions were governed largely by necessity, for there were no official sources from which reliable data could be had. How different now, for once each day, during the three hundred and sixty-five of each year, the faithful and intelligent voluntary observers are recording the maximum and minimum temperatures and rainfall over an area encompassing 3,602,990 square miles.

The data collected by the Climate and Crop Division is not provincial in its utilization. A recent request upon my office for a second monthly report was supplemented by the statement that the original copy "had gone abroad—was now in England selling land." So we see that these reports frequently partake of the nature of living apostles and distributors of information, "are as bread cast upon the waters to return after many days."

Numbers of controversies arise in the course of ordinary business affairs during a year, an equitable decision of which, without recourse to legal tribunals, is frequently arrived at through the medium of local voluntary stations. I have in view an issue between a railroad corporation and a merchant, the latter bringing suit for damaged goods. The railway company set up the defense that the damage was caused by delayed traffic, due to heavy washouts on the road. Recourse was had to the records of a neighboring voluntary station, and the matter was amicably settled.

In semitropical sections, statistics of rainfall and temperature greatly enhance the investigations of the entomologist in determining the peculiar conditions essential for the propagation of insect life. Data recently furnished from the records of voluntary stations opened up this line of investigation in Florida.

To emphasize the fact that all industries are beginning to utilize the records of the Bureau, a recent request from Germany for rainfall statistics from a certain portion of Florida will fully attest. The applicant was interested in the phosphate industry, and wanted to know the average rainfall during what is locally known as the rainy season. And so we might continue the citation, showing the great work being done by one division of the Bureau; and, in conclusion, it is but just to say that the Weather Bureau is a great storehouse of information, the utilization of whose data is only limited by the knowledge of its existence.

SNOW AND ICE MEASUREMENTS.

HERMANN VOLKER, St. Paul, Minn.

Having occasionally noticed great differences in the depth of snow and thickness of ice reported from stations at no great distance apart,

and understanding from personal experience, through my connection with the Central Office of the Weather Bureau, the importance attached to this subject, I venture a few remarks and suggestions upon the same with a view of improvement in the present method of measurements and consequent greater value of these data.

Remarks.—Snowstorms generally extend over a much larger area and are more evenly distributed than rainstorms; therefore, a reasonable agreement in the depth reported from neighboring stations might be expected. It is also true that the amount of snowfall is not influenced by the conditions of city and country; but it is a well-known fact that in cities snow drifts much more and more irregularly than in the country, and that evaporation goes on more rapidly even at temperatures far below freezing. In northern latitudes, the ground in the country is not often entirely without snow cover, after the season for it has set in, but in cities it happens repeatedly if the snowfall is light and at long intervals. Such measurements of the depth of snow on the ground as best represent the true depth with which the country is covered in general are most valuable to the interests for which these data are recorded. Telegraphic reports of snow whose depth is 0.5 inch or less are published in the snow and ice chart as "trace." Five-tenths inch is considered a valuable snow cover, especially from an agricultural standpoint; but, except when snow is actually falling, the ground is usually bare in many places when the amount is less than 0.3 inch.

Where possible ice is harvested from lakes. Ice companies clear away the snow as soon as the thickness of ice will permit, since the presence of snow greatly retards the growth of the ice. They make many measurements from day to day until the ice harvest commences, after which, of course, the cuts will show the thickness. The thickness of the ice from which the crop is harvested is considered to be the thickness for the locality, and therefore the proper amount to be recorded, reported, and published.

Suggestions.—Snow measurements to be exact should be made in the country; but as that is generally impracticable at regular Weather Bureau stations, they should be made as far out in the suburbs as possible, in places least exposed to drifting; a sufficient number of measurements should be made, and at reasonable distances apart, to assure the observer that a fair average of the surrounding country has been obtained. The amount that fell at the station since the last measurement should, of course, be added, if snow is falling at the current p. m. observations. An extra word should be added to the snow code, representing from 0.3 to 0.7, inclusive, as half an inch; trace should be represented by 0.3 or less.

Ice measurements should, when possible, be obtained from local ice companies, and from the spot where they expect to harvest. The Central Office should be informed, before the season opens, as to how and where snow and ice measurements are obtained, so that a statement thereof can be made when required or desired.

I believe that any improvements, such as mentioned above, will give satisfaction to the Bureau and to all interests concerned, and that every observer will, after the first quarter of the season is over, be pleased with the result obtained, in the better agreement of the amounts reported from neighboring stations, and in this way be compensated for a little extra effort in that direction.

BENEFITS OF THE WEATHER BUREAU TO WESTERN NEBRASKA.

J. C. Piercy, North Platte, Nebr.

I will mention only a few of the innumerable benefits of the Weather Bureau. The Bureau is of great importance to the western part of Nebraska, where the climate is so vital a consideration in settling the country. I am satisfied that were it not for this Bureau many counties which are now prospering under the advantage of its fertile soil would still be prairie. The first meeting of the Nebraska State Irrigation Association was held in North Platte, Nebr., in 1893, and being invited to speak before the association on the rainfall of western Nebraska, I stated that the rainfall was not sufficient for successful farming, and that irrigation was a necessity. This assertion has been fully verified, for the successful farmer of to-day is the one who irrigates. Thousands of acres of land are now irrigated where irrigation was not practiced a few years ago.

To show the importance of the precipitation data to the public, I will say that it is only a few days ago that the mayor of North Platte, who is an extensive landowner, requested to be furnished with the rainfall from 1875 to 1897, and had me certify to its correctness before a notary public. The dissemination of data compiled by the Weather Bureau has made this country a resort for suffering humanity. By personal observation I can say that hardly a day passes at this time of the year but that a sufferer from consumption (sometimes nearly dead) stops at North Platte in hope of being benefited by the dry and invigorating air, and I am happy to say that the climate improves them.

DEVELOPMENT OF THE DAILY WEATHER MAP.

By Edgar B. Calvert.

One of the best known features of the work of the Weather Bureau is the daily weather map issued to the public. The history of the development of this chart from the primitive carbon copy to the present well-known forms is quite interesting.

Some years prior to the establishment by act of Congress of the first weather service (Signal Service) February 9, 1870, daily weather maps were prepared by a few scientific men from reports gathered by private means. Prominent among these persons was Professor Cleveland Abbe, who has been with the Weather Service since its organization, and is now senior professor on the scientific staff of the Chief of the Weather Bureau. But it is the purpose of this paper only to briefly trace the development of the official daily weather map.

The first official weather map of the Weather Bureau was prepared in manuscript by Prof. I. A. Lapham, Chicago, Ill., on November 1, 1870, but it was not until January 14, 1871, that the work of manifolding the maps for distribution was begun at Washington. The first method of manifolding was by means of sheets of carbon paper placed between blank tissue maps. From 10 to 20 copies of the map were arranged together in this way and placed on some hard, flat surface. Impressions were made by means of steel dies and a mallet. It was a slow and laborious process, as each symbol and figure had to be stamped separately. These maps contained readings of barometer

and temperature, state of weather, wind direction and velocity, and precipitation, but no isobaric lines.

The manifold method was dispensed with on April 30, 1871, and in its stead a brass bed-plate map was used, on which all the cities from which reports were received were indicated in their proper positions by small square holes mortised in the bed-plate. Steel symbols, representing the eight wind directions and the different weather conditions, were placed in these holes so as to form a printing surface. Close to each of these holes slots were cut into which were set the figures showing in regular order temperature, barometer, and wind velocity. The plate so prepared was placed in an ordinary proof press and impressions printed therefrom. Weather forecasts, then called "probabilities," and a synopsis of the general weather conditions that prevailed within the area represented by the charts were first printed on the maps October 1, 1871. These, with some changes, have continued to be an interesting and valuable feature of the daily maps. The barometer and temperature lines were still omitted from the charts, but on October 30, 1871, when the lithographic process was adopted, the isobars were added. The bed-plate was not entirely dispensed with, as impressions were still taken from that on prepared paper, the highs and lows and lines added by hand, and the whole transferred to lithographic stones. On April 15, 1872, the isotherms first appeared on the chart. With few modifications from time to time in the kind of symbols used, number of reports indicated, shaded precipitation areas, etc., the same process has continued in use at the Central Office up to the present time.

After the adoption of the bed-plate and lithographic process by the Washington office the steel dies used in making the carbon copies were sent to a few of the stations of the Bureau, but their use was very limited.

In 1876, during the Centennial Exposition, an attempt was made to send the lines of the daily weather map by means of autographic telegraphy. The chart was telegraphed in this way each morning from the office of the Chief Signal Officer at Washington to the Signal Service Exhibit in the Government Building at Philadelphia, and there reproduced and distributed. However, this scheme was not afterwards continued because it was impossible to obtain an exact reproduction, especially at great distances.

In 1879 a contract was made with the New York Graphic for printing a weather map in its daily issue, and the first chart was published on May 9, 1879. In appearance it was very much like the chalk-plate maps now seen in the newspapers of some of our large cities, but the zincograph method that was used in preparing the plate is little known or used at the present time. This chart was first drawn on paper with copying ink and then transferred to a metallic base. The lines and figures were then carved or etched in this metallic base, which was used as a mold for casting the plate from which the printing was finally done. The Graphic continued to print this chart for some years, for which service the Government paid $10 per day. In addition to this about $15 per day were expended for the material used in preparing the chart and for telegraphing reports and instructions for drawing the barometer and temperature lines. The work of telegraphing the lines was accomplished by means of a lettered and numbered diagram covering the daily map at Washington,

a key to which was in the hands of the observer at New York. At that time no one outside of the forecast official in the Washington office was permitted to draw barometer and temperature lines and to locate highs and lows.

Prior to 1886 charts could not be issued from stations in large quantities, for the reason that there was no process whereby they could be prepared speedily and without great expense. It was not practicable to place a lithographic plant at the different stations of the service. In 1886 the cyclostyle method was tried with success, and in August of that year it was put into operation at the New York station. Within the next few years it was introduced generally throughout the service. This process is quite simple, and, to some extent, is in use at the present time. A specially prepared stencil sheet of waxed or paraffined paper, not unlike parchment in appearance, is tightly stretched on a hinged frame that is fitted over a zinc bed-plate. The map to be copied is placed on the bed-plate under the stencil sheet, and the stations marked in the latter by means of a perforating punch. The lines and figures representing the temperature, barometer, wind velocity, etc., and the symbols indicating wind direction and state of weather, are cut into the stencil by means of a peculiar pen that consists of a small corrugated or milled wheel made to revolve freely. The corrugations on this wheel cut into the stencil paper, leaving a series of small holes through which the ink can be forced by means of a regular printer's roller. In printing off each impression it is required that a blank map be placed on the zinc bed-plate, the frame lowered, and an inked roller passed over the stencil. By this process remarkably clear and artistic maps were often made, depending on the skill of the person preparing the stencil. However, there are objections to this method of printing the weather map, as an accident at the beginning of the issue may ruin the stencil and render it impossible to make further prints therefrom.

In 1890 the milliograph was substituted for the cyclostyle, and it is now used by the Weather Bureau in nearly all work where a stencil is required. This process differs from the cyclostyle only in the fact that the stencil sheet is placed over a pad thoroughly saturated with ink. Impressions are made by a dry roller passing over the blank map placed above the stencil. The advantage of this method over the other is that the tendency to break the stencil is reduced to a minimum, and a certain number of legible maps always can be obtained. However, after a few hundred maps have been run off by the milliograph the copies become smeared and illegible.

On August 20, 1892, there was published in the Atlanta Constitution a reproduction of the weather map for that day, and each day thereafter the current weather map appeared in the columns of that paper. This map was prepared by the chalk-plate process, now well known and much used in newspaper work. A preparation of chalk is made to adhere to a smooth steel plate, forming what is known as the chalk plate. With a sharp steel stylus an outline of the map of the United States and the weather data is drawn through the chalk down to the hard, steel surface. The plate is then placed in a casting box, into which molten type metal is poured. The hot metal fills in all the places cut by the stylus, the result being a perfect cast which can be locked up in a newspaper form. When the work is well done the impressions made from such a cast are sharp and distinct.

Since 1892 many of the large newspapers of the country have made a feature of publishing in their columns the daily weather map.

In 1893 the first map stencil was prepared on a typewriter at the Minneapolis station. Since that time several stations have made the stencils in this way, a typewriter with special characters being required. A few months ago the Chief of Bureau directed that experiments be made with a view to determining whether the small charts, such as are used in the chalk-plate process, could be used for the typewriter form. The results have been satisfactory, and directions have been issued to gradually substitute these small charts to be prepared on the typewriter for the large chart issued by the hand-stencil process. This will result in not only a more legible map, but in economy of expense and time, as but one small stencil will be required.

In the early part of 1896 the present chalk-plate and printing process was adopted. It does not differ materially from the method used in preparing the newspaper map. The charts printed in this way are eminently satisfactory, and artistic work is done at many stations. An unlimited number of perfectly legible copies can be printed from the plates. On account of the great first cost of the stereotyping apparatus and complete printing outfit, press, type, etc., required in issuing maps in this way, it is not practicable to establish printing stations at any except the large offices. Printed maps are now being issued from 28 stations. These printed charts are of much smaller form than the old station issue, being about 16 inches long and 11 inches wide.

In a comparatively short time all the maps issued from stations will be of a uniform size, either in the printed or typewitten form. The following table shows the yearly issue of the weather charts :

Fiscal year.	Number of stations.	Number of maps issued.		Fiscal year.	Number of stations.	Number of maps issued.	
		Annual total.	Daily average.			Annual total.	Daily average.
1887	31	175,387	480	1893.....	74	2,165,642	5,935
1888	40	383,230	1,050	1894..... ...	73	3,136,892	8,593
1889	29	859,027	2,355	1895.....	76	3,609,215	9,890
1890	41	1,068,862	2,925	1896...	77	3,802,600	10,430
1891	52	1,198,899	3,280	1897	80	4,625,250	12,600
1892	70	1,817,120	4,980	1898	84	5,239,800	14,350

It is seen that the issue of the daily weather maps has greatly increased since the year 1886, when the first attempt was made to supply the general public in this way with information in regard to weather conditions.

Since 1870 there have been several changes in the hour of taking the observations telegraphed for entry on the forecaster's chart and the daily weather maps, a corresponding change in the hour of issuing the published maps being necessary :

Washington time.—November 1, 1870, to August 25, 1872, 7:35 a. m., 4:35 p. m., and 11:35 p. m.

August 25, 1872, to October 31, 1879, 7:35 a. m., 4:35 p. m., and 11 p. m.

November 1, 1879, to December 31, 1884, 7 a. m., 3 p. m., and 11 p. m.

Changed to seventy-fifth meridian time, January 1, 1885 (difference, 8 minutes).

Seventy-fifth meridian time.—January 1, 1885, to December 31, 1886, 7 a. m., 3 p. m., and 11 p. m.

January 1, 1887, to June 30, 1888, 7 a. m., 3 p. m., and 10 p. m.

July 1, 1888, to date, 8 a. m. and 8 p. m.

From the date of issue of the first tissue chart by manifold process in January, 1871, to July 1, 1888, the Washington map was published thrice daily, although the charts prepared from the morning observations were the only ones generally distributed to the public. From July 1, 1888 to September 30, 1895, the maps were issued twice daily. On the latter date the p. m. chart was discontinued, and since that time there has been but one daily issue.

It is not possible in this paper to state in detail the history of the station charts. For a number of years they were published twice daily at the larger stations of the service, but it was found that in most of the cases one issue a day would be sufficient. At but few stations are maps now prepared for general distribution both from the morning and evening observations. These changes do not refer to the manuscript pencil charts prepared at forecasting centers for use by the forecaster in making twice-daily predictions of expected weather conditions, and, whenever necessary, warning of marine storms, frosts, cold waves, heavy snows, etc. The original plan of entering with pencil the data for each observation, whether tridaily or bidaily, on blank tissue charts as fast as received over the telegraph wires has never been changed. The maps so prepared are used almost exclusively for forecasting purposes and study.

From the beginning of our national meteorological work, it became apparent that the daily weather maps would not be complete without daily reports from the regions north and south of the United States. It was not possible at first to obtain telegraphic observations from many stations in the United States west of the Mississippi River, due to the absence of telegraphic lines. The early bulletins contained data from Omaha, Nebr., and Cheyenne, Wyo., reports from Corinne, Utah, and San Francisco being added about January 1, 1871. As fast as it was possible to do so, stations were located in every section of the western country, keeping abreast of the march of progress and civilization as the electric telegraph brought that vast, undeveloped country into close touch with the Eastern States. Efforts to obtain daily observations from the regions beyond our northern boundary met with early success. On November 13, 1871, an arrangement was made with the Canadian Government for an exchange of reports, whereby the meteorological office at Toronto would telegraph to us their observations and we, in turn, give them such reports as they desired. This cooperation has continued up to the present time. It has resulted in vast benefit to both countries, especially since stations were located in the British Northwest Territory, where most of our cold waves make their appearance. By means of observations taken at stations in the United States, the Canadian Meteorological Office is enabled to forecast the numerous storms that move down the St. Lawrence Valley out into the ocean.

The work of obtaining daily reports from the countries and islands to the south of us proved a more difficult task. Professor Abbe makes reference to this subject in his paper which appears in a

report of the Meteorological Congress held in Chicago in 1893. He says:

> The need of more reports from the West Indies, especially during the hurricane season, was very deeply felt in 1871, * * * but this invasion of foreign countries, and especially the transmission of cipher dispatches, presented many objections which could be overcome by international courtesy. Three stations were opened in 1872 and began to report in August or September of 1873. Three more were opened in 1874.

General Myer and General Hazen, during their administrations of the Signal Service, made repeated attempts to inaugurate a system of reports from the West Indies, but with discouraging results. In their annual reports these officers referred to these failures and attributed them to imperfect arrangements for cabling, incompetent foreign observers, and lack of sufficient appropriations.

During General Greely's administration of the weather service as Chief Signal Officer arrangements were made for receiving daily cablegrams from a cordon of stations in the West Indies, the observations being made by native observers from instruments furnished by the United States Government. On account of its great expense this plan did not continue long in operation. It gave way for a system whereby special observations were taken and cabled by native observers whenever conditions indicated the presence or approach of a tropical hurricane. During Prof. M. W. Harrington's administration as Chief of the Weather Bureau provision was made for receiving special observations from Yucatan, in Central America. The value of the observations from the West Indies and Yucatan was demonstrated again and again in forecasting destructive hurricanes approaching the Gulf and south Atlantic coasts of the United States. It was not until the summer of 1898 that the complete weather map, the dream of the men who engaged in the early struggles for the organization of the National Weather Service became a reality. During the recent war with Spain, when the scenes of naval operations were for the most part laid in the waters of the Caribbean Sea and Gulf of Mexico, the necessity for daily observations from these regions became apparent. Our blockading squadron could not then enter Cuban harbors. As the hurricane season approached the possibility of our fleet being scattered and seriously damaged by one of these severe storms became a matter of serious concern to the President and the naval authorities in Washington. At the urgent solicitation of Honorable James Wilson, Secretary of Agriculture, Congress authorized and made appropriation for a meteorological service in the West Indies, to be established by the Weather Bureau under the direction of the President. Trained officials from the regular service of the Weather Bureau were sent to man the West Indian stations, taking with them complete equipments of standard instruments. Kingston, Jamaica, was selected as the temporary headquarters of the new service, and arrangements were perfected for cabling the reports twice daily to that place, and to the Central Office at Washington. On August 11, 1898, thirty-five days after Congress authorized the service, West Indian reports were entered on the daily weather map at Washington. The value of this work to the commerce and shipping of all nations trading with those islands of the sea was soon demonstrated. On September 24, 1898, the Weather Bureau official at Kingston gave warning, to all ports that could be reached, of a

hurricane that proved to be one of the most terrible that has visited that section of the world since 1861.

It was also in the summer of 1898 that successful negotiations were made with the Mexican Telegraph Company for an exchange of meteorological reports. Observations from four Mexican stations are now received during the hurricane season and entered on the Washington map. It is intended to place standard American instruments at these places, so as to make the reports therefrom thoroughly comparable with our own.

The mechanical appliances for producing weather charts are sufficiently perfect to meet all present requirements, and the area covered by the daily observations is great enough for practical forecast purposes. It is now possible to produce the charts at stations in unlimited quantities and in legible form.

ESTABLISHMENT AND INSPECTION OF VOLUNTARY, RIVER, AND COTTON-BELT STATIONS.

J. B. Marbury, Atlanta, Ga.

Since the transfer of the Weather Service of the United States to the Department of Agriculture, in 1891, the relationship between this service and the agricultural interests of the country has grown closer and closer each year. The territory covered by the observations now embraces the major portion of every State and Territory in the United States. The development of the National Climate and Crop Service has been far more rapid than its most sanguine supporters in the beginning dared hope, until its work now ranks second only to that of making the daily forecasts, the widespread distribution of which is made possible through the various sections of the National Climate and Crop Service.

This branch of the Weather Service, when first organized, had the active cooperation of only a few of the States, but the importance of the undertaking soon manifested itself so plainly that the Weather Bureau completed the work, and now the service embraces every State and Territory. There are at present more than three thousand voluntary observation stations, whose records are becoming more and more valuable in the formation of the climatic history of our country as the period covered by the observations is lengthened. These records are especially valuable to the farmer and others interested in agricultural pursuits, since the stations for the most part are located in small rural towns and villages, where the instruments can be exposed near the ground, free from the many artificial influences found in our more thickly populated cities. The conditions of the atmosphere thus obtained are closely allied with those directly affecting plant life.

The reports from our voluntary observers form a most important aid to the student of climatology, since they embrace many sections of the country which are not and can not be represented by the regular paid Weather Bureau observers. To be of the fullest value it is imperative that the instruments and records be correct, the observations carefully and accurately taken, and the best possible exposure be given the various instruments. I am convinced, by personal experience, that nothing can contribute more toward securing reliable

and accurate observations than an occasional inspection of voluntary stations by the directors. It is certainly very important that the men or women who are willing to freely give so much of their time and labor to the work be properly instructed in the very beginning as to the best manner of performing the duties required and, from time to time, encouraged by a personal visit from the director who could thus help them over many temporary obstacles much easier than by letter. These visits would, I am sure, not only increase the accuracy of the reports, but would awaken a new interest in the work. We all need a little encouragement now and then, and when given in person it goes a great deal further than when given on paper, which is cold and unsympathetic at best.

I think each new station should be started under the personal supervision of the director whenever possible. A few moments devoted personally to instructing one of no experience in handling the instruments will give far better results to both the observer and the Bureau than many letters.

To one who has had no experience with a self-registering thermometer or a rain guage, it is a difficult matter to grasp their proper management from the pamphlet of instructions or from letters; especially is this true with observers who are men of limited education, who, when they see the instruments for the first time, think it impossible for them to master the situation and it not infrequently happens that it is only after the utmost persuasion that they are willing to accept the position. Many of this very type often prove to be most valuable observers.

This country has by far the best equipped weather service in the world as well as the best and most extensive field for its operations, and it should certainly be made of the greatest practical as well as scientific value.

The expense connected with the inspection of the voluntary stations would be small when compared with the good results. With but few exceptions the railroads throughout the country would willingly furnish free transportation, so that the only expense would be for meals and lodgings which, in many instances, would be gladly furnished by the party visited. It seems to me that the results would far more than counterbalance the outlay, and I am sure a marked improvement would be seen in a comparatively short time. I have talked with several railroad officials on this subject, and each one has expressed his willingness to aid in every way possible.

In evidence of the incorrect exposure of the instruments that often exists I will cite one or two of several instances that have come to my notice during the past few years. Upon visiting one station in Georgia I found the thermometers attached to the west side of a building, and the only obstruction to the direct rays of the afternoon's sun was a black umbrella. It took but a few moments to remedy this evil. A second observer had his thermometers on the north side of his house as required, but close in the corner where the chimney to his cookroom joined. The instruments thus received considerable artificial heat from the interior. Another had his thermometers hung in his hall and would open a door at either end a few minutes before taking an observation. I have little doubt that many similar experiences have been met by some of the officials present to-day.

Two other classes of observers needing the personal attention of

the officials in charge of their sections are the river and the cotton-region observers. With many of these there is often as much as or more trouble than with the voluntary observers, since they, in many instances, do the work simply for the money consideration, while with the voluntary observer, the interest he has in the subject prompts him to use the utmost care. The trouble with some of these latter classes is due as much, or more, to carelessness as to ignorance, and they need a little instruction now and then.

It would probably not be necessary to visit these stations as often as once a year except in rare cases. The importance of correct river observations will be fully recognized when we consider the value of the data in determining the proper location of water-power plants, as well as the effect of floods or extreme low water upon commercial and agricultural interests.

Water power has always been recognized as the best and cheapest means of running stationary machinery, and with the more recent inventions and improvements in electrical appliances making possible the long-distance transmission of power a new era in water-power development has been brought about. It is rapidly replacing the earlier methods of generating electricity for lighting our cities and furnishing power to our factories. Under the old methods factories had to be built along the courses of the streams, but there is no longer any such need. The more modern plan of placing the generating plant on the streams, and by means of wires transmiting the power to any point where it is needed is infinitely better. Capitalists are now erecting these plants on the banks of many of our rivers and water courses to furnish light and power to adjacent cities, but before they are willing to expend their money they naturally desire to know from official statistics all about the flow of water in the stream, whether it is likely to give sufficient power the year round, or whether there is danger of its drying up at certain seasons. In short they want to be able to ascertain the discharge of the stream every day in the year. These data can only be furnished from the various river records. It is therefore plain that these records should be carefully and accurately kept, for in computing the discharge at different stages a discrepancy of a few inches in the gauge readings will cause serious errors.

Similar reasons exist for the inspection of cotton, corn and wheat region stations, but it will be impossible and unnecessary to give them in this paper.

STORM SIGNALS ON THE GREAT LAKES.

J. H. Cox, Chicago, Ill.

The agitation for a national weather service originated with Espy, Redfield, Loomis, and Henry on the Atlantic coast, but was soon taken up in the Lake region. Owing to the many disasters which overtook vessels during stormy weather on the Great Lakes, especially on Lake Michigan, Dr. I. A. Lapham, of Milwaukee, advocated a storm warning service as early as 1844. In a letter written in 1858 to the president of the Detroit and Milwaukee Railroad Company, which had just begun to operate a winter service of steamers between Milwaukee and Grand Haven, he said :

One of the greatest difficulties and dangers against which you will have to contend arises from the sudden stormwinds which so often and so unexpectedly put the sailor upon his hardest service to keep his vessel from shipwreck. During most of the time the winds on the lakes are light and not unfavorable to navigation, but after a number of days of fair weather a sudden and often unexpected change occurs, the wind hauls around toward the westward and blows for several hours a strong gale. On the ocean such gales are not so much dreaded, for there is sea room enough to enable the vessel to ride out the storm, but upon the lakes it is often only by the most extraordinary efforts that the vessel can be kept "off-shore."

It was mainly through the agitation of Dr. Lapham and Gen. H. E. Paine, both of Milwaukee, that Congress passed a resolution in February, 1870, creating a weather service. Immediately after its establishment Dr. Lapham was appointed assistant to the Chief Signal Officer and was assigned to the Chicago station with instructions to issue storm warnings for the Lake region; in fact Chicago was then, as now, a forecasting center for the lakes.

The first dispatch sent out from Chicago was dated at noon on November 8, 1870, and was directed to be bulletined at once by the observers on the lakes. It was as follows:

High winds all day yesterday at Cheyenne and Omaha; a very high wind reported this morning at Omaha; barometers falling, with high winds at Chicago and Milwaukee to-day; barometer falling and thermometer rising at Chicago, Detroit, Toledo, Cleveland, Buffalo, and Rochester; high winds probable along the lakes.

Such was the beginning of the storm warning service. The warnings were first confined to advisory messages, then to storm signals, afterwards to storm and cautionary signals, later to storm and information signals, until at present forecasts are sent to all lake stations daily, in addition to messages ordering the hoisting of storm signals, the latter being issued only when severe storms are expected.

All storm signal orders are verified, each station having its own distinct verifying velocity. These verifying velocities have been changed from time to time, depending upon the elevation and exposure of the anemometers. A proper and satisfactory verification of storm signals is as difficult to secure as a satisfactory verification of ordinary weather forecasts. For purposes of comparison, I have taken from the monthly reports of storm signals of the nine stations on the upper Lakes the number of verifying velocities with direction which have occurred during the past five years. The minimum verifying velocity at the station has been taken as the basis, ranging from 42 miles at Chicago down to 28 miles per hour at Marquette and Green Bay. These winds occur more frequently in March than in any other month, leading with 14 per cent, February and April following with 12 per cent. (See Table I.) The stormwinds are sporadic particularly during the warmer weather. In but two storms during the 5-year period have verifying velocities occurred at all nine stations on the upper Lakes, and in but 15 storms have such velocities been reported at eight stations. If the force of storms was felt, as a rule, equally on all the lakes, and the existing verifying velocities were relatively exact, all stations would have approximately the same number of such velocities during a period of years. Yet there is a great difference between the number of stormwinds at the various stations, ranging in five years from 317 at Marquette to 85 at Grand

Haven. (See Table II.) While there may be reason for some difference, it is impossible to believe that dangerous storms are four times as frequent at Marquette as at Grand Haven. Topographical features play a most important part in the force of the wind and its direction, often permitting winds from certain directions only. (See Table III.) At Duluth, a storm velocity from the east, southeast, south, or west has not occurred in five years, while the percentage of northeast to northwest winds, which may be considered on-shore, was 83 per cent of the total. At Marquette, these winds are mainly from a southerly direction, 72 per cent being off-shore. At Sault Ste. Marie, the percentage of northwest winds alone is 77 per cent; at Alpena, the percentage of westerly or off-shore winds is 70 per cent; at Port Huron, 81 per cent; at Milwaukee, 71 per cent; at Green Bay, 61 per cent; at Chicago, 66 per cent is off-shore; but Grand Haven, with its unusually small number of stormwinds, has 71 per cent of them from the dangerous or on-shore direction. Of the nine upper Lake stations, six have 70 per cent of the stormwinds off-shore, and the remaining three have 74 per cent of these winds on-shore.

The great percentage of northwest winds at Sault Ste. Marie is remarkable, but it is hardly fair to consider these winds entirely on-shore, as the town is situated on St. Marys River below Whitefish Bay; moreover, the velocity of northwest winds is always much greater at the Sault than out on Lake Superior. In fact, the wind velocity at that point from the northwest is so great that it is always out of all proportion to the barometric gradient. There is no doubt that there is a strong suction down the valley, which runs from northwest to southeast, and the wind continues high from Whitefish Point down, long after the wind on the lake has become only fresh or light.

At Green Bay practically no high winds from northeast to southeast occur, which is due to the high cliffs on Limestone Ledge, situated about two miles to the east of the station. The minimum velocity required to verify signals at Chicago is 42 miles per hour, but when the wind exceeds 34 miles from the north or northeast for a few hours, but very few vessels will leave port. A velocity of 40 miles from the northeast after four or five hours will absolutely prohibit navigation at the southern end of Lake Michigan. Yet a southerly wind of 45 or 50 miles per hour just suits vesselmen going northward. Captains say it is extremely difficult to take vessels out of Duluth Harbor after the wind has been blowing 30 miles an hour from the northeast for a few hours, but that a 45-mile wind from the southwest is very favorable.

On September 4, 1897, the writer was proceeding westward from Sault Ste. Marie to Marquette, keeping about 3 or 4 miles from shore. A strong southwest wind was blowing during the entire day. The records at Marquette show that the wind averaged from 30 to 32 miles an hour, which is a storm verifying velocity. Yet on account of its being off shore, the wind had no appreciable effect upon the boat. The captain of the vessel stated that an on-shore wind with much less velocity would compel him to seek shelter in the nearest harbor.

In answer to an inquiry from me, the observer at Marquette recently said:

Southerly winds do cause our register to record higher velocities than north

or northwest winds, notwithstanding the high ridge of hills or mountains extending east and west, and just 1 mile south of the station. I have given this subject a good deal of thought, and am of the opinion that the deficiency of wind movement from the north and northwest is because the anemometer is only 10 feet above the crest of a hill, which extends east and west and is located about 600 feet north of the station. My reason for this presumption is that captains coming into port frequently report heavy on-shore winds outside the harbor, while within the city the wind is hardly 60 per cent as strong. Presque Isle is 3 miles north of the station along the Lake shore. When the estimated velocity is 30 to 35 miles northerly at that point, our register records about 22 to 26 miles. I will request an extra anemometer at an early date, and have it installed at Presque Isle for comparison with our record. I believe that the verifying velocity of off-shore winds should be increased, and that of on-shore winds reduced. To make a plain and unbiased statement, southerly winds are no impediment to navigation and of no consequence to any one, even though attaining a velocity of 60 miles an hour from the south, as occurred September 21, 1893. A northerly wind of 17 miles velocity at the station in three hours almost prohibits navigation, except by the best vessels, and a 22-mile wind for four hours will have filled the harbor with vessels seeking shelter, including such vessels as the *Northwest* and *Northland*.

In a recent communication the observer at Port Huron said:

A 25-mile wind from a northerly direction, especially from the north to northeast, causes a very heavy sea at the southern end of Lake Huron, as the wind has a long sweep down the Lake; and if it continues blowing any length of time the largest vessels lay over and wait for the sea to run down. Steamers with other vessels in tow are unable to make any headway, and their officers consider it is simply a loss of fuel to try. Navigators do not mind a 30 or 40 mile southerly wind when bound up the Lake, as it helps them along in their course.

On February 20, 1898, the steamship *City of Traverse* left St. Joseph, Mich., bound for Milwaukee, Wis. It encountered nothing stronger than fresh winds, but nevertheless, the vessel within an hour after leaving port, ran into a tremendous sea from the north, due to a gale which had blown the day before, and also to the high winds which were still continuing farther down the lake. The captain was obliged to abandon his plan of reaching Milwaukee and ran southwestward to Chicago for shelter, having nearly all the movables on board, such as dishes, broken to pieces. The inability of the vessel to proceed on its course was due entirely to the tremendous sea, as it actually passed through no strong wind whatever.

The question of sea room, referred to by Dr. Lapham in his letter forty years ago, receives most important consideration at the hands of sailors on the lakes, when on the windward shore. Whenever possible, captains take the leeward shore, moving along under its protection, often when it would be impossible for them to make any headway on the opposite side of the lake. It is of almost daily occurrence for the Chicago weather bureau office to advise vesselmen as to what course to follow on the run down the lake, in order to avoid on-shore winds.

It is surprising what little effect off-shore winds have on vessels. In order to cause a high sea, the wind must have a sweep of many miles. It is the heavy sea that causes so much trouble to shipmasters, as a gale, unless accompanied by heavy seas, is not to be feared. The effect of a gale is more easily apparent upon the fresh water of the lakes than on the ocean, where the water is heavier. However, during summer squalls of short duration well built vessels are seldom troubled, as the high wind must continue for some time in order to make a sea.

It is not strange that by far the greatest percentage of stormwinds is from a southerly direction, as the most common track of storms over the upper Lakes is directly over Superior, causing a general southerly current in front of the disturbance. The barometric gradient, as a rule, is much greater in front of such storms than in the rear, so that when the wind shifts to west and northwest it is generally with less velocity. Moreover, strong southerly winds almost always occur with rapidly rising temperature, the thermal gradient playing a most important part in the production of such winds. While the colder northerly winds may move with less speed, yet the air is denser and the momentum or striking force is probably therefore greater. In this connection it may also be said that the destructive force of heavy seas upon vessels increases as the temperature of the water decreases.

It is my opinion that the verifying velocities should be revised, increasing in nearly every case the verifying velocity of off-shore winds and decreasing that of on-shore winds. The need for this revision is particularly evident at such places as Marquette, Port Huron, and Chicago. Southerly verifying velocities often occur at Marquette in connection with disturbances moving over Lake Superior, which are not in the least dangerous. A storm verifying velocity should be a wind which is actually dangerous to shipping.

By supplementing the record of Marquette with a wind record at Presque Isle, and that of Sault Ste. Marie with a record at Whitefish Point, data would be furnished that would be most interesting and valuable. As the wind record at the Sault is not a fair indication of the wind's force on Lake Superior, I think that its verifying velocity from the northwest might with good reason be increased.

Again, it might even be advisable not to assign any verification to storm signals. Frost warnings are not verified, though the writer believes that it is easier to secure a proper and fair verification of frost warnings than of storm signals.

TABLE I.—*Percentage of verifying velocities, by months, for each station on the upper lakes, 1893 to 1897, five years.*

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Duluth, Minn.	5	14	10	13	8	7	6	6	9	6	7	9
Marquette, Mich.	6	11	11	9	7	5	4	5	13	13	9	7
Sault Ste. Marie, Mich.	8	14	15	7	8	4	3	3	12	9	11	6
Average for Lake Superior	6	13	12	10	8	5	4	5	11	9	9	7
Green Bay, Wis.	8	8	13	12	19	6	2	2	6	11	7	5
Milwaukee, Wis.	12	18	17	15	9	1	1	3	6	7	5	5
Grand Haven, Mich.	13	15	15	16	6	1	1	5	5	5	12	6
Chicago, Ill.	9	8	15	13	10	7	3	3	6	6	11	9
Average for Lake Michigan	11	12	15	14	11	4	2	3	6	7	9	6
Alpena, Mich.	13	15	15	11	11	2	2	2	6	4	9	10
Port Huron, Mich.	7	11	18	10	9	3	2	4	8	9	12	6
Average for Lake Huron	10	13	17	10	10	2	2	3	7	7	11	8
Average for the upper lakes	9	12	14	12	10	4	3	4	8	8	9	7

TABLE II.—*Total number of verifying velocities for each month for each stat on on the upper lakes, 1893 to 1897, five years.*

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
Duluth, Minn	5	16	11	15	9	8	7	6	10	7	8	10	112
Marquette, Mich	19	35	36	27	22	17	14	15	41	41	28	22	317
Sault Ste. Marie, Mich	20	34	35	16	18	9	6	7	27	20	25	14	231
Green Bay, Wis	10	10	16	15	24	8	2	3	8	14	9	6	125
Milwaukee, Wis	18	27	25	22	14	2	2	5	9	10	8	7	149
Grand Haven, Mich	11	13	13	14	5	1	1	4	4	4	10	5	85
Chicago, Ill	20	18	33	29	22	15	6	6	12	13	23	21	218
Alpena, Mich	15	19	19	12	13	2	3	3	7	5	11	12	121
Port Huron, Mich	16	24	41	23	20	7	5	10	17	21	27	14	225

NOTE.—The months in which no wind-signal forms were prepared are estimated in both tables.

TABLE III.—*Percentage of stormwinds from each direction for each station on the upper lakes, 1893 to 1897, five years.*

	N.	NE.	E.	SE.	S.	SW.	W.	NW.
Duluth, Minn	1	30	0	0	0	16	0	53
Marquette, Mich	4	0	0	11	32	29	4	20
Sault Ste. Marie, Mich	0	3	2	18	0	6	4	67
Green Bay, Wis	30	3	0	2	4	24	21	16
Milwaukee, Wis	6	7	4	12	4	30	21	16
Grand Haven, Mich	2	1	13	6	7	6	15	50
Chicago, Ill	6	11	3	13	22	29	10	5
Alpena, Mich	2	1	9	17	1	17	19	34
Port Huron, Mich	8	5	2	4	13	33	18	17

CAN LONG-RANGE WEATHER FORECASTS BE MADE WITH ANY DEGREE OF ACCURACY OR PROFIT?

A. B. CRANE, Pensacola, Fla.

Realizing the depth of the subject I have chosen to present to your notice, and my inability to cope scientifically with it, I beg to express the hope that the will be taken for the deed, and the few practical points enumerated herein, however imperfectly discussed or presented, be acceptable to this body and that sharp criticism be reduced to a minimum. My idea is to encourage the study of the subject more than to lay claim to theory.

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The question is, can long range forecasts be made with any degree of accuracy or profit? My answer is, Yes, and No.

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It seems to me, therefore, that it is, as yet, unnecessary to go out of our own atmosphere to look for coming changes in the weather. For years the most distinguished philosophers have made efforts to discover even periodic recurrence of weather changes of longer and more regular intervals than those between successive cyclonic centers, which are known to be of weekly or bi-weekly cycles; that is to say, in a general way a recurrence of similar conditions are known to exist for short periods, but no one can foretell the double cyclonic or anticyclonic period that controls or will control.

Yet there are many who believe the moon governs the weather; in fact, it is a popular belief, but nothing has been discovered to bear the test of comparison except in a slight and imperfect manner.

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I will, therefore, now take up that portion of long-range forecasting which I do believe in, or rather have reason to suspect is susceptible of improvement so that it can be put to practical use. This relates to cycles in weather.

There are geographic locations that receive almost regularly their quotas of weather and have striking climatic characteristics. We know that California has her wet and dry seasons; that the maximum rainfall occurs on the northern coast of Washington, amounting to slightly over 100 inches annually, and from that center gradually diminishes; that the reverse (almost and proportionately) is true of the Gulf and Atlantic sides, of course with few local exceptions; therefore, it is not a hard matter to look for rains in proportion and in season for those localities or districts.

The long-range forecaster can not well fail here, but he nevertheless relies upon, and has access to, the Weather Bureau records in formulating his prognostications.

Take another example: In a country where there are no mountains, there is little rain. The floating vapor which pervades the atmosphere and is drifted by the force of the winds requires the refrigerating tops of lofty mountains to gather and condense it, and send it back in showers or rains.

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For generalized districts such as above mentioned we can readily understand and see why seasonal climatic changes occur. There are other localities also which show a marked periodicity or recurring types of weather. One point in particular I remember is Montgomery, Ala. For that place a graphic cross-section map was prepared, showing the daily, monthly, and yearly averages of temperature and precipitation, also their fluctuations. For several months the dates on this chart coincided with the actual normal conditions and variations closely enough to cause comment by the station force.

There may be other observers who have found similar results, and if so, it would be well for them to make a further study of the matter.

Now, to show that a very variable result may follow, and in about the same geographic division, I will state that I made a similar cross-section map for Pensacola, Fla., for the month of September, and could find no coinciding periodicities at all. The maximum temperature for that month was as liable to occur in the last part of the month as the first, or in the middle; the minimum showed a better agreement, however, and likely to occur sometime in the last decade, although it once occurred as early as the sixth of the month. The rainfall data shows no agreement whatever, save that the normal or average amount is 4.80 inches; that 11.54 inches fell in the year 1880 and 0.32 in 1883; that one, two, or three years in succession the rainfall would be either above or below the normal; and that the heaviest falls occurred scattered throughout the month. The wind data shows even a greater disparity in comparison; the mean hourly velocities vary considerably, the least being but 6.4 miles, in 1885, and the greatest, 10.3, in 1897. The maximum velocities ranged between 19 and 50 miles per hour, blowing from all directions, and

without any recognizable date or period in the month. The only definite sequence, then, was that the lowest temperature of the month might be looked for in the last decade.

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By tabulating the data it will be found that, in a general way, storms of considerable severity usually occur on the Gulf and Atlantic coasts from March 1 to 31, and also in the autumn anywhere from the middle of July to October 1. This much meteorologists know and predict, and I refer to the forecasts made for the Hydrographic Pilot Charts of the North Atlantic, but no one can positively assert, or predict, that such and such will occur on such and such dates a year, or even a month, in advance. * * * Again, one may predict that, in the event of a large deficiency in rainfall for one season, that deficiency will he made up or counterbalanced sooner or later, although a deficiency may exist for longer than one or two seasons. In fact, such was the case at Pensacola last year. The deficiency began in April continuing throughout with a shortage of 16.40 inches at the end of December; even during the next year there was a general scarcity of rain up to the first week in August, when rains set in and a total of 18.58 inches occurred, breaking the record for the month, and to a large extent counterbalancing the deficiency. I feel confident that another wet spell will set in during the fall and early winter which will compensate, if not run over. But I can not say at just what time or dates it will occur. * * * The wisest long-range forecaster can not say just when the counter action will take place.

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On one occasion I remember, a believer in the romancers called at my office for some information regarding the weather outlook. I gave it to him, the forecast happening to be for fair weather. "Why," he said, "that's funny; Mr. So and So, the weather prophet, says rain." "Well," I replied, "the funny part is that you believe in the long-range prophet." In this particular case, as in several others, I purchased the prophet's book, and sure enough there it was in plain English calling for rain on that particular day, when as a matter of fact the weather and day were as fine as could be wished for. The person in question, at my solicitation, turned back to former predictions, and together we carefully examined the records to verify this prophet's handiwork, much to the chagrin of the unknowing one, for he could scarcely find a day on which the conditions agreed with the forecast.

That gentleman left the office a wiser man, and with a better understanding of the works of long rangers, as well as a higher opinion of the Weather Bureau. From several verifications of this class of forecasts I have been unable, with liberal construction and marking, to find any that run over 40 to 60 per cent in value, and oftentimes not that high. This sort of work is worse than useless, and utterly impracticable for business purposes, to say nothing of the disadvantage it is, or may be, to business people, health seekers, builders, and pleasure parties. A uniform standing forecast of fair weather and stationary temperature will yield better results, or at least give a percentage of nearly 75, and not be so harmful.

Now, we come to another test question. There is no going against record and absolute fact. As an example I will cite that severe win-

ters, or rather freezes, in the State of Florida occurred in the following years: 1747, 1766, 1774, 1799, 1828, 1835, 1850, 1857, 1880, 1884, 1886, 1894–95, and that the best any one can make of these figures is that there appears to be seventeen years on an average between successive freezes, but note the disparity between the years in the whole time, it can scarcely be made into or called a cycle; the shortest interval is four years, and the longest twenty-nine years. Where is the long-range forecaster, or "prophet" if you will, that can safely say a year in advance, when the State of Florida will receive her next baptism of frigidity with its disastrous results.

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Science is defined as consisting simply of the systematic arrangement of facts, and more facts are needed before the artist, however energetic or skilful, can unfold that intricate study, long-range weather predictions.

THE WEATHER AS A TOPIC OF CONVERSATION.

A. S. Brendle, Schæfferstown, Pa.

I have never had much patience with that quite numerous class of critics who are in the habit of adverting facetiously to the keen interest manifested in the weather by many people in farming communities, as though it were quite ludicrous for any one to select as a topic for conversation the present and prospective effects of sunshine and rain, heat and cold, wind and calm. The farmer, it seems to me, has as much right as anyone to be interested in what pertains to his own vocation in life. The farmer knows best why it is that he is interested in the weather. It is inconceivable that he should be indifferent to what lies so close to his well-being. Whether the season will afford a proper proportion of heat and moisture to mature his crops is a question of success or failure with him. It is essential to his prosperity that there should be neither excessive rain nor hurtful drought. Consequently, who can blame him if, with anxious face, he often scans the skies, or if he chooses to regard the weather as a good topic for conversation. I, for one, can see nothing to condemn in so reasonable a practice. The most intelligent men in every country believe that it is worth while for the National Government to employ specialists carefully to study the weather indications and publish forecasts for the benefit of the people at large. It is right that the Government should do this, for it concerns the welfare of the whole country. Whether we are willing to admit it or not, we are all more or less interested in the weather; and it is certainly no laughing matter if people see fit to discuss weather facts or probabilities.

Some one has laid down the canon of conversation, that people should converse of what they understand best or know most about, of course not to the exclusion of everything else, but within reasonable limits. If that canon is sound, and it rests on good common sense, we must justify the farmer when, even in the social circle, he speaks by preference of the weather and his crops. And who will say that it is not as edifying to practical mortals to discuss the weather as any other topic in the whole range of human contemplation? The merits or demerits of the latest work of fiction or of the most approved system of metaphysics are trivial questions as com-

pared with one which involves the very existence of the whole human family.

The most learned investigator of nature can not consider it beneath his dignity or unworthy of his attention to study the laws that in their ever-varying combinations bring about the various meteorological conditions and changes. Those who think that the subject is only worthy of the rustic and the boor are miserably mistaken, and all their ill-timed jibes and flings recoil upon themselves.

The subject has its poetic side, too. The phases of the weather represent the varying moods of Nature, the mother of us all. She smiles in the genial sunshine and weeps in the summer rain; she whispers in the gentle zephyr and threatens in the lightning's flash; her frown is in the thunder-cloud, and her benediction in the sparkling dew drop. To be indifferent to the weather is to be indifferent to the moods of Nature herself.

DISTRIBUTION OF FORECASTS BY MAIL.

P. F. Lyons, St. Paul, Minn.

In compliance with a circular letter from the Climate and Crop Division of the Weather Bureau, dated July 9, 1897, the following method of locally distributing unaddressed cards, weather forecasts, and maps by mail was introduced at this station, August 9, 1897, and extended February 10, 1898, so as to include the weather maps.

The initial arrangements with the local postal officials consisted in preparing lists in triplicate of the addresses in the respective letter-carrier routes, of those entitled to service, and supplying two copies of each to the superintendent of carriers, who in turn supplied each carrier concerned with one, giving necessary instructions as to its use, the superintendent retaining the others for reference and use in case of confusion or loss of those in the possession of the carriers; the third set was filed at the station, and on it the additions, transfers, or other changes that may be made by Postal or Weather Bureau officials are duly noted.

The postmaster at first thought that, in order to comply with law, it would be necessary to put a number on each unaddressed card corresponding to the carrier's number who was to deliver it, and then have all deposited in the mail box for assortment, the same as ordinary mail. I concluded that but little labor in preparation of cards and no time in their delivery would be saved in that way; he next agreed to try the method of putting the cards intended for the respective carriers in bunches, and putting a number on the outside one corresponding to that of the carrier who was to deliver it, and then have all deposited in the mail box for assortment; but even then there was some time lost, for the matter had to be reassorted, or had to go through other hands before reaching the carriers; finally we arranged to have the packages transferred direct from the Weather Bureau to the carriers' room, in which is a large set of pigeon holes or carriers' boxes, each of which has a number corresponding to that of the carrier whose package it is intended to hold. The packages of cards are arranged at the Weather Bureau office, and taken directly to the carriers' boxes by our station force almost invariably

about 10 a. m., or in ample time for delivery through the business portion of the city before 12 noon of each day. By the old method, the delivery could not possibly be made before 2 or 3 p. m. of each day.

With the view of further reducing time and labor, I suggested to the superintendent of carriers that all cards and maps be made up in a single bunch, and then taken by the station force to a place in the post office designated expressly for them, and that each carrier, as he prepares to start over his route, go to the designated place and help himself to the number required; but the answer was, "that would be contrary to rules or regulations," and could not be agreed to.

Suggestions.—Could not such rules or regulations be modified by the Post Office Department, at request of the Department of Agriculture or other officials empowered to act, so that the suggestion, or something similar made in the preceding paragraph, may be applied to the mail matter in question; but there may be objections on the ground that, where a carrier has a large number of addresses on his list, it would tax his time, etc., to count out the necessary number. Very well, grant that; but there are a large number of carriers whose lists call for but from one to five cards or maps, and it seems that it would be no extra trouble to them to go to the common pile where, no doubt, they would find the cards or maps placed as proposed and help themselves.

There are 67 postal carrier routes over which cards or maps are distributed from this station, consequently, that number of packages must be prepared and put in place at the post office for distribution daily; but the above statement applies only to the card forecasts; there is a second delivery of maps, but of which no carrier delivers more than three at a time, and in such cases surely it ought to be as easy for him to help himself from the pile as to get the maps from special boxes.

UTILITY OF HYGROMETRIC OBSERVATIONS.

ARTHUR PENNELL, M. E., Kansas City, Mo., and Prof. H. A. HAZEN, Washington, D. C.

Mr. PENNELL. I have been investigating, for the last two years or more, methods for utilizing the hygrometric properties of the atmosphere for condensing exhaust steam, ammonia, etc., in localities where water is either scarce or expensive.

In obtaining the necessary data, the United States Weather Bureau has been my principal source of supply, and must be so to others engaged in similar lines of research.

In many manufacturing lines, an intelligent use of this hygrometric data would show some quite surprising economical results. For example, in the meat-packing business. The carcasses, after being dressed on the killing floor, are run into chill-rooms to have the animal heat abstracted and the temperature reduced to about 38° F., or below this point by artificial refrigeration. This operation entails a shrinkage averaging 2 per cent of the weight. This is due to the evaporation from the meat of that weight of moisture.

As now carried on, each 1,000 pounds of beef, for example, gives off 38,000 thermal units. The above-mentioned moisture congeals on the coils of the refrigerating plant in the shape of hoar frost and has to be swept away from time to time.

Were the meat, on its way to the chill-room, to travel slowly down an alley up which a strong draft of air, at the local average temperature of 55° F. and a dew-point of 44° F. was passing, the condensed moisture above mentioned would evaporate at the expense of the animal heat and be carried off into the atmosphere, thus, of itself, reducing the temperature of the meat to about 60°.

The meat, thus cooled down, would, on reaching the chill-room, only require about 16,000 thermal units to reduce its temperature to 37°. Thus, the amount of artificial refrigeration needed would be only about 42 per cent of that which is now required.

Even in hot, humid weather in summer, which is the most disadvantageous, the required percentage of artificial cooling would not rise above 80 per cent of that now required, while in cooler weather it would sink to zero. In order to safely accomplish this economy, the operator would have to know the temperature and dew-point of the atmosphere, and regulate the time of exposure and volume of draft accordingly.

In my own particular line I cool warm water by its own partial evaporation into the atmosphere, and utilize the cold for refrigerating plants, manufacture of ice, cold storage, etc.

In order to congeal water, it is very certain that the heat it contains must be abstracted from it and disposed of by some natural process, practicable even in the hottest summer weather. This is generally effected by pumping large quantities of water out of wells at an average temperature of probably 60° and passing it over ammonia condensers, thereby heating it to, say, 90°, and then running it off to waste. Each pound of water takes up 30 thermal units on its trip. A ton of refrigeration calls for 284,000 such thermal units. Consequently, at least 9,464 pounds of water must be pumped for each ton of refrigeration. In practice about 50 per cent more is required.

There are many places where refrigeration is desired and where water is either scarce or expensive. In such cases recourse must be had to atmospheric evaporation. All the different devices to effect this, my own among the number, work on precisely the same principle that a splash of water on a hot pavement shortly evaporates into air at the expense of the heat in the pavement. The hotter the pavement the quicker the action; also, the drier the air and brisker the breeze the quicker the action.

I use a tower, galvanized-iron clothing, and an iron skeleton, into the lower part of which the warm water is driven in a very fine spray from the center. The spray fills the lower part of the tower, up which a current of air is passing, either induced by natural draft or forced by a fan. The spray consists of very minute globules, the surface of which vaporize into the air at the expense of the heat of their interior. The spray strikes the periphery of the tower, trickles down, and falls into a catch-basin below, and can thus be used over and over again.

In designing such a tower, it is necessary to know the highest temperature the atmospheric dew-point ever attains in the locality and the temperature by the dry-bulb thermometer when that maximum dew-point occurs. The volume of such air required to reduce the temperature of some given weight of warm water to, say, 10° above the dew-point can then be determined, and the tower designed accordingly.

The number of manufacturing processes in which something has to be dried, i. e., moisture has to be abstracted, must be legion. They mostly use a high temperature, obtained artificially, and small volume of air. As competition grows keener, the managers of these establishments will be forced to investigate the scientific basis of their processes to secure better economy by using lower temperatures and larger volumes of air, and, in doing so, will learn of the benefits to be derived from the work carried on by the United States Weather Bureau.

Prof. HAZEN. Every one will admit that moisture, temperature, pressure, and other atmospheric conditions tend to cross the country from west to east in circular or oval waves. In the case of pressure these ovals (highs and lows) are brought out very distinctly by the isobars, but in the cases of moisture and temperature we find the oval shape entirely obliterated by the latitude variation, that is to say, the rapid diminution in these elements as we go from south to north serves to entirely obliterate the oval condition which, however, we know must exist. All attempts to overcome this difficulty by constructing charts showing changes in twelve and twenty-four hours have failed for the reason that they indicated purely *relative* rather than *positive* conditions, that is, a large plus change may be due to a simple filling up or a restoration of a disturbed equilibrium, and not to any actual advance of a wave. We very much need then some method of analysis which will enable a direct comparison of these conditions.

A partial solution of the problem is to be found in a vertical projection of these fluctuations side by side at a single station, and this will show just when one point of the crest of a wave passed the station, but such a curve falls far short of a definite and clear view of these waves in their entirety, as they cross the country. Now all barometric readings are reduced to a common horizontal or sea-level plane, and, as this is very nearly flat in the long run, all pressure waves (highs and lows) are shown in their proper proportions. If, now, it were possible to reduce moisture and temperature in the same way to a horizontal plane, we might hope to obtain these waves more clearly defined. By making a proper allowance for the effect of the latitude variation a fairly satisfactory reduction might be made, but this would be an extremely tedious operation. On the other hand, we may assume the decade or the twice-a-month normal as a flat plane, and fluctuations from this plane would give us these waves in their true proportions. In ordinary practice, however, we find that in any single decade the moisture value on each of the ten days may be far above or below the corresponding normal for that decade, that is, the moisture value may fall entirely below the assumed normal plane each day of one decade, and above that plane in the very next decade. To overcome this difficulty we must abandon all pressure lines or isobars for each tenth of an inch, as well as isotherms for each 10° and lines of equal moisture content, and substitute for them an oval indicating the departure from the normal of pressure, moisture, or temperature, each covering a certain definite area in square miles, say a 10° square on the map or less. Of course, the size of the oval is immaterial, but a much better comparison can be instituted between the waves if the ovals are nearly of a size in any one case or on a single map. This can be easily attained if we note by

inspection the size of oval that can be best drawn from the figures.

Such wave crests have been drawn for more than two months, and have already shown that we have here a most powerful means of studying the origin and progress of such waves. For example, it has been found that almost invariably the wave of moisture has precedence over that of temperature and pressure, and that the pressure wave lags considerably behind both the others. This is almost a startling corroboration of the facts already brought out as to the movement of moisture, temperature, and pressure on Mount Washington; that is to say, a wave of high temperature accompanies a low-pressure wave, but the change to a lower temperature occurs first in the upper air and is thence transferred to the earth. It would also appear that the positions of these wave crests will enable us ultimately to determine the direction in which a high or low, for example, will move in the next twlve hours. If the last suggestion proves true, this will become a very important method of study, as all will readily recognize.

WIND VANES.

C. P. Cronk, Cape Henry, Va.

The vanes now in use are very large and heavy, and though they may work fairly well in strong winds when first put up, they are not sensitive enough in light winds, and their great weight develops so much friction that considerable force must be exerted to turn the arrow. The weight of the long and heavy vane rod is added to the mass of the vane of which it is really a part. Now, as friction, either rolling or sliding, is directly proportional to the pressure of the two surfaces. it is evident that the vane itself should be made as much lighter, and the vane rod as much smaller and shorter as consistent with utility.

As to the form and mechanism of the most suitable vane, it is suggested that experiments be made with the Weather Bureau anemometer by taking off the cups and arms and substituting an aluminum arrow, to be not heavier than the arms and cups. The dial case could be made use of, perhaps, as a connection box. It is, at any rate, believed that the connection box should be as close to the vane as the dial is to the cross arms supporting the cups.

But one objection to the light vane can be thought of. It may lack the steadiness of a large one, but from a few crude tests it is believed that slight but constant vibration of a small, light vane will simply tend to keep broken any adhesions that might result from its remaining too long in one position. There would be as little friction as in the anemometer.

This communication is no more than an introduction to the subject of improvement in wind vanes. I have neither facilities nor the time for the necessary investigation with attendant experiments.

In conclusion, it is desired to invite attention to Professor Abbe's Treatise on Meteorological Apparatus and Methods, pp. 188 and 189, and particularly to the paragraphs from which the following quotations are taken:

It is obviously unphilosophical to overcome this difficulty [oscillation] by adding to the inertia of the vane and by retarding it with an overwhelming amount of friction, which varies from day to day, and which is greater at the

beginning of motion than when motion is established. The true plan is to allow the vane to represent all the actual deviations of the wind, and then so deal with the record as to obtain a mean direction.

The lighter vane gives the true state of things for strong as well as gentle winds; its oscillations are generally smaller and its rotations fewer in windy weather, because the onward motion is so quick that an impulse from one side is immediately succeeded by one from the other, thus causing short, quick movements of the vane.

FORECASTS OF PROBABLE TEMPERATURES.

I. M. Cline, Galveston, Tex.

The demand for more definite forecasts of certain elements of the weather will, from time to time, present themselves from localities where there are extensive interests of any character which are subject to injury by abnormal weather conditions. This desire on the part of the public for more definite information concerning future weather conditions has been developed by the accuracy of the Weather Bureau forecasts of warmer, colder, frosts, cold waves, and windstorms which have been used advantageously by all classes. These general forecasts and warnings have, indirectly, through the protection which they have afforded, caused the extension and development of industries which now call for still more definite forecasts to enable proper action for their protection.

Some years ago when the development of the sugar and trucking interests commenced in southern Texas on a large scale, with expectation of rapid development, the operators of plantations called on me for such warnings as could be furnished them. The fortunes of some individual planters had been wrecked in previous years by a single freeze, and the main object was to guard against disasters of this character. Complete arrangements were made to furnish the general forecasts and warnings issued by the Weather Bureau to the sections engaged in these industries. Forecasts of stationary temperature, warmer, colder, frosts, and cold waves were extensively used by sugar planters and truck growers on the Texas coast as guides for the protection of their crops, but these were found too indefinite for their special needs. Sugar planters supplemented the information contained in the official weather forecasts and warnings by having the temperature and pressure at all stations from Texas northward telegraphed them, both morning and evening, at their expense. In addition to this they would telegraph during the day to points over the eastern Rocky Mountain slope in periods of critical temperature making inquiry as to weather conditions, hoping that they might obtain information that would enable them to protect their crops. Several neighboring plantations are, as a rule, connected by telephone so that one planter can keep an entire community advised as to coming weather conditions. In the winter of 1894–95, I was frequently called on by planters who, in their requests for information, explained that the weather forecasts, to be of material benefit to them, must specify about the temperature expected to occur. They stated that no definite action could be taken for the protection of their crops on forecasts of colder, cold waves, etc., unless the temperature to be expected could be named in the forecast. Protection is not needed frequently, but when occasion does arise to require it a vast saving

results if warned in time, and without warning the loss is always serious. A forewarning of a change of only a few degrees in the temperature when near freezing is a matter of great importance. Sugar cane when well matured will stand in dry weather a temperature of 30°, and when rain or sleet accompanies the fall in temperature it will stand a temperature of 26° without material injury. Planters also desire temperature warnings when temperatures are expected to fall to about 32° for use in the protection of seed cane in the fall and the young cane when coming up in the spring. The truck growers state that in the care of hot beds and certain classes of vegetables a warning of the probable temperature is of great importance when it is expected to fall to near freezing.

In order to determine whether or not I could forecast the temperature as desired by representatives of these industries, the forecasting for twenty-four to thirty-six hours in advance was carried on during critical weather in the winter of 1894–95. This experimental forecasting resulted in sufficient success to warrant a request to the Chief of the Weather Bureau for authority to issue special forecasts of expected temperatures for the sugar and trucking interests of this section. In August, 1895, Prof. Willis L. Moore, authorized the issue of the special forecasts as recommended.

These special temperature warnings have been issued for three winters. A complete tabulated statement of all of them is given at the close of this paper. The warnings have been all that sugar planters and truck growers desired. By the use of these forecasts sugar planters have been enabled, in each season, to cut and windrow their cane before the freeze injured their crops; and they have not in a single instance cut their crops when unnecessary. Truck growers who used the warnings have in all instances saved their crops from injury. No freeze to injure sugar cane or trucking interests has occurred during the three winters without timely warning. On the strength of warnings of November 27, et. seq., 1896, the large sugar cane crop then standing was cut and windrowed and thus saved from injury by the freeze which followed. On the strength of the warnings of December 2 and 3, 1897, all the sugar cane standing at that time, a large acreage, was cut and windrowed and saved from injury by the freeze.

Regarding the verification of warnings, I consider the warning justified if the temperature falls low enough to damage unprotected crops, and I assume that if the temperature which occurs is within 4° of that forecast either above or below, the warning may be considered verified. Fifteen special temperature warnings were issued in the winter of 1895–96, three in the winter of 1896–97, and eleven in the winter of 1897–98. Fourteen (93 per cent) of the fifteen warnings issued during the winter of 1895–96 were necessary for the protection of trucking interests while only one warning was not justified. All three (100 per cent) of the warnings issued during the winter of 1896–97 were justified, and no unnecessary warning was issued. Of the eleven warnings issued during the winter of 1897–98 nine (82 per cent) were necessary, and only two were not justified and required the unnecessary protection of vegetation. During the three winters twenty-nine warnings were issued on which crops were protected and only three, or about one in ten, caused unnecessary protection.

On the assumption that a warning is verified if the temperature

which occurs is within 4° of that forecast, eleven (79 per cent) of fourteen warnings of 1895–96 were verified at Galveston and thirteen (87 per cent) of fifteen issued for the territory 50 to 100 miles from Galveston were verified by taking the lowest temperature recorded in that section; all three (100 per cent) of the warnings of 1896–97 were verified both at Galveston and 50 to 100 miles from Galveston; nine (82 per cent) of the eleven warnings issued during the winter of 1897–98 were verified at Galveston and all except one (91 per cent) were verified by the lowest temperature which occurred 50 to 100 miles from Galveston.

The public is quick to appreciate efforts on the part of the Weather Bureau to supply information of the character desired as well as to make improvement in the forecasts. Those interested lose no time in taking advantage of any class of warnings which they can utilize. The truck growers when they feel certain that they will be promptly warned twelve to thirty-six hours in advance of approaching injurious temperatures, plant their fields with a view to protecting their crops when advised by us. In this section, where only occasional light freezes occur, and, as a rule, protection is practicable throughout the winter, vegetable and berry crops are cultivated during the winter months for shipment to northern markets and toward the close of the winter the most tender varieties of plants are pushed under protection so that this section now furnishes the earliest vegetables to northern markets.

The sugar planters put in larger crops of cane, and cut only as used by the mills when they feel sure that they will receive definite warnings far enough in advance to enable them to cut and windrow their cane before it is damaged by freezes. Every additional day that cane can be left standing in the fields improves the product, hence the great value of timely warnings. Besides these features the ability to grind as fast as cut from the fields results in a large saving to the producers. Through the warnings of the approach of injurious temperatures planters can take the risk of drawing the earth from the cane early in the season, and let the sun warm the roots to start an early growth. If injurious temperatures are forecast the cane is covered and protected and then uncovered again, as soon as favorable weather returns, without materially retarding its growth.

During periods of critical temperatures the local office of the Weather Bureau at Galveston is constantly in telephonic communication with those who have interests to protect, and especially with some part of the sugar and trucking region, by means of the long-distance telephone. The time of one man is frequently required all day at the telephone answering calls. The demand for information, over the long-distance telephone, from places outside of Galveston has become so great that the telephone company has placed a long-distance telephone in the office of the Weather Bureau at this place for the benefit of their patrons in other portions of the State who use the telephone, at their own expense, in communicating with this office. This is cited as indicating the interest in the warnings and the vigilance with which planters seek definite information.

Speaking for the southeastern portion of Texas I do not believe that it would be putting it too strongly to say that the general public would be as much inconvenienced without the Weather Bureau as they would be without the post office.

Regarding the utility of special temperature forecasts I desire to say that, while it does not appear essential that forecasts of probable temperatures be made for entire districts, a material improvement would result by issuing special forecasts giving expected temperatures for all localities where interests such as sugar cane and early truck growing are extensively engaged in. Such warnings can be utilized to the greatest advantage in the semitropical sections near the Gulf coast and in portions of California, where products can frequently be kept growing unprotected until January and by occasional protection throughout the winter. These warnings will also prove advantageous in all sections where extensive gardening for market is commenced early in the season, for damage often results from temperatures near freezing when there is no frost formation.

It was my intention to have given in this paper a description of the weather types which give injurious temperatures near the Texas coast, and the deductions followed in forecasting probable temperatures, but find that it must be deferred to some future time when I will prepare a separate paper on that subject.

Special temperature forecasts made at Galveston, Tex., for the district within 100 *miles of that place, for the benefit of sugar planters and truck growers.*

WINTER OF 1895-96.

Date.	Temperatures forecast for following day at—		Temperatures which occurred on the following day at—				Difference between temperatures recorded and those forecast.*	
	Galveston.	50 to 100 miles from Galveston.	Galveston.	Houston.	Stafford.	Columbia.	Galveston.	Lowest 50 to 100 miles from Galveston.
1895.	°	°	°	°	°	°	°	°
November 25	37	32	.....	Frost.	.....	.....	.....	.....
November 26	.....	.....	36.6	33.8	28	31	− 0.4	− 4.0
December 2	34	28 to 25	.....	Frost.	.....	.....	.....	.....
December 3	.....	.....	37.0	34.6	28	32	+ 3.0	+ 3.0
December 3	36	30 to 28	.....	.....	.....	.....	.....	.....
December 4	.....	.....	39.4	30.1	27	28	+ 3.4	− 1.0
December 19	38	32 to 28	.....	Frost.	.....	.....	.....	.....
December 20	.....	.....	42.2	36.0	32	31	+ 4.2	+ 3.0
December 30	32	28	.....	.....	.....	.....	.....	.....
December 31	.....	.....	40.0	29.0	29	29	+ 8.0	+ 1.0
1896.								
January 3	30-27	24 to 20	.....	.....	.....	.....	.....	.....
January 4	.....	.....	31.7	32.0	28	32	+ 1.7	+ 8.0
January 4	36	27	.....	.....	.....	.....	.....	.....
January 5	.....	.....	39.2	29.7	25	28	+ 3.2	− 2.0
January 23	38	30 to 27	.....	Frost.	.....	.....	.....	.....
January 24	.....	.....	46.0	36.8	33	32	+ 8.0	+ 5.0
January 25	42	34	Frost.	Frost.	.....	.....	.....	.....
January 26	.....	.....	43.8	37.9	34	36	+ 1.8	0.0
February 7	40	30	.....	.....	.....	.....	.....	.....
February 8	.....	.....	38.7	37.0	34	39	− 1.3	+ 4.0
February 8	.....	36	.....	Frost.	.....	.....	.....	.....
February 9	.....	Frost.	.....	37.5	33	40	.....	− 3.0
February 13	39	33	.....	Frost.	.....	.....	.....	.....
February 14	.....	.....	44.0	38.0	30	35	+ 5.0	− 3.0
March 3	40-36	35 to 32	.....	.....	.....	.....	.....	.....
March 4	.....	.....	58.8	54.0	50	50	+18.8	+15.0
March 18	44	37	.....	.....	.....	.....	.....	.....
March 19	.....	Frost.	45.6	43.0	40	43	+ 1.6	+ 3.0
March 19	44	36	.....	Frost.	Ice.	Frost.	.....	.....
March 20	.....	Frost.	45.5	37.8	34	37.5	+ 1.5	− 2.0

*The plus (+) and minus (−) signs indicate whether the temperatures were above or below those predicted.

Temperature forecasts made at Galveston, Tex., for territory within 100 miles of that place, for the benefit of sugar and trucking interests.

WINTER OF 1896–97.

Date.	Temperatures forecast for following day at—		Temperatures which occurred on the following day at—					Difference between temperatures recorded and those forecast.*	
	Galveston.	50 to 100 miles from Galveston.	Galveston.	Houston.	Stafford.	Columbia.	Brenham.	Galveston.	Lowest 50 to 100 miles from Galveston.
1896.	°	°	°	°	°	°	°	°	°
Nov. 27..	38	30	.....	.....	.....	.....	.....	.....	.....
Nov. 28..	.....	.....	40.7	38.2	36.0	36.0	30.0	+2.7	0.0
Nov. 28..	34	28	.....	.....	.....	.....	.....	.....	.....
Nov. 29..	.....	.....	34.7	35.5	35.0	32.0	33.0	+0.7	+4.0
1897.									
Jan. 25..	27	22	.....	.....	.....	.....	.....	.....	.....
Jan. 26..	.....	.....	27.0	25.0	18.0	24.0	.....	0.0	−4.0

WINTER OF 1897–98.

1897.									
Dec. 2..	40	32	.....	.....	.....	.....	.....	.....	.....
Dec. 3..	.....	.....	37.5	38.0	32.0	36.0	30.0	−2.5	−2.0
Dec. 3..	30	24	.....	.....	.....	.....	.....	.....	.....
Dec. 4..	.....	.....	30.0	27.0	26.0	27.0	23.5	0.0	−0.5
Dec. 16..	38	31	.....	.....	.....	.....	.....	.....	.....
Dec. 17..	.....	.....	44.9	39.2	37.0	39.0	31.0	+6.9	0.0
1898.									
Jan. 15..	40	32	Frost.	Frost.	Frost.	.....	.....	.....	.....
Jan. 16..	.....	.....	44.0	37.0	32.0	32.0	34.0	+4.0	0.0
Jan. 25..	36	29	.....	.....	.....	.....	.....	.....	.....
Jan. 26..	.....	.....	43.2	39.5	37.0	40.0	35.0	+7.2	+6.0
Jan. 26..	40	32	.....	Frost.	Frost.	Frost.	.....	.....	.....
Jan. 27..	.....	.....	42.8	39.2	36.0	35.0	36.0	+2.8	+3.0
Feb. 2..	39	31	.....	.....	.....	.....	.....	.....	.....
Feb. 3..	.....	.....	39.0	35.0	32.0	33.0	28.0	0.0	−3.0
Feb. 5..	42	34	.....	.....	.....	.....	.....	.....	.....
Feb. 6..	.....	.....	48.2	41.2	36.0	34.0	36.0	+6.2	0.0
Feb. 20..	43	34	.....	.....	.....	.....	.....	.....	.....
Feb. 21..	.....	.....	41.3	36.5	33.0	32.0	33.0	−1.7	−2.0
Mar. 2..	42	33	.....	.....	.....	.....	.....	.....	.....
Mar. 3..	.....	.....	42.0	41.0	37.0	40.0	36.0	0.0	+3.0
Mar. 23..	40	32	.....	.....	.....	.....	.....	.....	.....
Mar. 24..	.....	.....	43.8	39.0	37.0	39.0	35.0	+3.8	+3.0

*The plus (+) and minus (—) signs indicate whether the temperatures were above or below those predicted.

AN OFFICIAL OF THE WEATHER BUREAU: HIS DUTIES AND QUALIFICATIONS.

B. S. Pague, Portland, Oreg.

The following is submitted as the personal opinion of one who has had nearly eighteen years' service in the meteorological bureau of the United States:

In newspapers, periodicals and books, except in those of a scientific or semiscientific character, it is always found that the Weather Bureau official is mentioned as "The Weather Man," or in terms of like import, at once assuming a humorous tendency. For the past ten years, efforts have been made to eliminate this lighter vein from all publications. Like poison once taken, antidotes work slowly though surely, so that the humorous is only slowly passing away. The Weather Bureau official has been laboring for years to place his work upon a sound and dignified basis, endeavoring to make the work done

each day so valuable that its importance and merit would command the respect of the public. Hence, his chief characteristic is his desire to be of value to the people. The observations and reports are each so important that seriousness enters into his work, even to the most minute detail; promptness, careful attention and accuracy mark the work of the Weather Bureau official. To succeed in anything, whether in manual labor, or in the most abstract problem of science, it is necessary that the individual possess ability, energy, liberal views and a discerning mind. To succeed in a scientific pursuit, and especially in one that is viewed with skepticism by the masses, requires a most fertile brain, sound judgment and accurate deduction.

The qualifications of a man are often difficult to determine. A powerful writer is one having knowledge, logic, rhetoric, thought, and language constantly at his disposal. A successfal orator in addition to the preceding must have a physical force and personal presence that commands the attention and respect of his hearers, a well modulated voice and the power to emphasize the important points of his discourse. An official in the Weather Bureau may possess all these, yet not succeed in his work. The Weather Bureau requires so many and varied duties that the special qualifications are at times difficult to determine, but when once found are sure to be recognized.

Offices located in rural communities, where the official performs only the routine duties required are not always made as valuable as they should be; it may be difficult to determine how offices so located may increase their importance, how the official can make himself of value to the community, and how secure the respect and good will of the people in his work; yet this can be done, if the individual is devoted to his work, if he has a love for his duty, if he is working for the good of the Bureau and not for his own material good or pleasure. In cities the scale of work is so large that few are found qualified to conduct it so that the greatest possible good is accomplished. The practical work of the Weather Bureau is being demonstrated daily, and hence the stations of the Bureau are growing in importance; the individual must grow or else fall behind in the procession of events. To keep pace with the development of the work of the Bureau requires active, intelligent men; men who are quick to grasp ideas and to put them into execution. The time is past when no forward move on the checker board of work can be made without the suggestion or sanction of the Central Office in Washington.

An official is charged with certain specific duties, but his instructions are general; the latitude given the subordinate is such that his ability may be developed and his work thereby become of greater value to his immediate community. The successful official associates with the people of the community in which he lives He makes a study of their needs and moulds his work accordingly. If he lives in a dry region, he studies the water supply and endeavors to lay before the people the necessity for a certain course of action in order that the available climatic elements may be made as valuable as possible; if in a wet region, there are numerous features at his disposal that can be utilized with profit. In an agricultural, horticultural or stock region various interests can be served. In commercial communities a wide field is offered for successful work and equally as great opportunities are offered in marine communi-

ties so that no matter what the conditions may be surrounding an official, if he be mentally alert, he can increase the value of the work. Every office is primarily of equal importance; as the surroundings are increased, whether for commercial or industrial pursuits, so are the avenues for valuable work increased. He who is great in small things can be great in large affairs, so that growth is open to all, no matter what the local environments may be. Every office depends upon the other. No central office, state or national, can be successful in the work of the Weather Bureau without loyal support from every minor office, no matter how meagre its equipments are. Never was one cog-wheel more dependent upon others for its own motion than are the larger offices upon the smaller. The official in high rank is as dependent upon the lower in rank as the lower is dependent upon the higher.

These are some of the features found in the work of the Weather Bureau, and the one who possesses the qualifications to fully utilize the many and varying opportunities presented to him is the one who is, or will be, successful. The Weather Bureau official should be able to express himself in writing or speaking so as to command the respect of his readers or hearers. He must possess a pure character so as to have the moral respect of the people. He must work upon broad and liberal lines with the people in the community in which he resides. He must be a man of intelligence, of force of character; must possess in a high degree the attributes that are necessary to success in any and every important undertaking in life. He should study the people, visit their fairs and expositions, and be connected with the management of them; attend and take an active part in agricultural college institutes. Every gathering of agricultural and horticultural people should be attended by a Weather Bureau official. He should know the soil and climatic conditions and be able to discuss them intelligently. He should be in close touch with public schools and colleges, and especially with agricultural colleges and technical schools; interest the teachers and educators in his work; be connected with, and participate in, the work of scientific societies, and be closely related to the newspaper people and have the most cordial relations with them.

These are some of the qualifications most necessary to make the work of the Weather Bureau a success. The people must be educated to the value of and benefit arising from the work in which the official is engaged. When he has accomplished this, progress, advancement, and success will reward him. So far as possible the individual must not, *per se*, be prominent. The Weather Bureau should always be more prominent than the official. The Bureau lives while the official passes away, but as the Bureau rises in the estimation of the public, so will the official rise. The Bureau must be of value to the people, the official of value to the Bureau. The personal reputation and importance of the official depends upon his union with the Bureau and his faithfulness to it and to the people.

The Weather Bureau is in its infancy. It has a great future. The individual can not float above with the tide; he must stem the current, and, with the Bureau, by force of attainment, character, and steadfastness of purpose win success.

APPENDIX A.

On the evening of October 14 a banquet was given which was attended by members of the Convention and a number of guests, among whom were the Hon. Joseph H. Brigham, Assistant Secretary of Agriculture; Hon. John M. Thurston, United States Senate; Hon. D. H. Mercer, M. C.; Hon. William Pitt Kellogg, E. Rosewater, Esq., editor of the Omaha Bee; Sands Woodbridge, Esq., of the Omaha World-Herald, and others who, with the Weather Bureau officials, numbered about one hundred.

As the speeches at the close of the banquet were by men who have achieved distinction in public life, journalism, and other pursuits requiring the highest order of ability, it is deemed appropriate, as far as practicable, to give their remarks, as showing the estimate they place upon the value of the Bureau's work.

No provision was made for a stenographic report of the banquet speeches, and it is wholly due to the kindness and industry of Mr. Robert M. Reese, stenographer to the Honorable Secretary of Agriculture, and to his efficiency and thoughtfulness that it is possible to give the remarks of part of the speakers. Some excellent speeches, however, were not taken by the stenographer, a matter of regret, as those delivered by the Hon. D. H. Mercer, Prof. Cleveland Abbe, Hon. John R. Sage, Director B. S. Pague of the Oregon section, and others were able and interesting.

Professor Moore presided and spoke as follows:

Gentlemen of the Weather Bureau and Honorable Guests: Here, and over the broad areas stretching away 1,500 miles on either side of us, was founded a republic exemplifying the most sublime confidence in man. Others had built upon vested rights, traditions, or theories, but here for the first time was founded a system of government based upon the natural and inherent rights of man. Such a system of government gave the world its first ideals of liberty, reconciling authority with liberty, liberty with authority, and solving at once and for all time the great problem of human government. Now, what has been the result of the benign conditions of soil, climate, and government under which we exist? Why, we have been able to meet and hold our Weather Bureau Convention, midway between the great oceans, with the vast mineral wealth of the mountains towering on our west and the great fruitful plains on our east; to enjoy the society and the hospitality of a highly cultivated and thrifty people, where but a few years ago the virgin soil of the prairie was yet unbroken; to witness out here at the second edition of the White City, the material and physical manifestations of the agriculture, the arts, and the commerce of a people unequaled for their skill, their inventive

genius, and their energy by any other race or amalgamation of races throughout the world [applause].

What have been the results of these Divinely given conditions—these Divinely given physical, geographical, meteorological, and geological conditions? Here all Nature has conspired to make a great people, to build up a great civilization. Recently a great national crisis confronted us. But, gentlemen, the seeds of national virtue and patriotism planted at Lexington, Yorktown, and Lake Erie, watered and fertilized by the blood of Gettysburg and Appomattox, and nourished during the past thirty years by the invigorating sunshine of the most free and liberal education with which a people was ever blessed, have given to our armies in the field a sturdy and enlightened manhood which made Santiago possible, and which realized the magnificent victory of that grand old hero at Manila. What has been the result? Why, as Corporal Tanner recently said, "We have given to the world an eighth wonder; we have presented to the effete monarchy of Spain the grandest submarine navy the world ever saw!" [laughter]. We have shown, gentlemen, that the American people, notwithstanding the acrimony of their political discussions, have such sublime confidence in the wisdom, the patriotism, and the justice of the Christian statesman whom they have elected to preside over their destinies that all political parties will sustain him in the hour of the country's peril [loud applause].

But, gentlemen, we have grown rich, populous, and prosperous in the cultivation of the arts and sciences of the greatest of all countries, and to-day we are turning our eyes toward the sunny Tropics and toward the ethereal blue of the far away west in quest of other peoples upon whom we may stamp the impress of our institutions and the munificence of our American civilization.

The American people are adept in invention, in applying knowledge and science to the commerce and industries, not only of their own country, but of the world. And in no way is that aptitude better shown than in the meteorological service of the Department of Agriculture.

The great raisin industry of California testifies to the value of our warnings. The shippers of the perishable produce of the country, the marine interests of the Great Lakes and of the Atlantic Ocean, all testify in the most emphatic terms of the millions annually saved through the warnings of this meteorological institution. I listened to the president of one of the largest sections of the British Association for the Advancement of Science, at Toronto two years ago, and heard him declare that the United States Government was far in advance of all other governments in its meteorological knowledge and in applying that knowledge to practical affairs. I give a few of these facts for the benefit of those not familiar with our work.

Probably in no case within my range of vision, certainly in but few cases, is that citizenship I have just extolled better illustrated, or its possibilities better shown, than in the life and achievements of him who, simply as a farmer's lad, entered the service of his country, and by valor rose to the rank of colonel; who served his State in the State senate; who lately presided over one of the greatest organizations in this country—I mean the National Grange—and at a still later period was called into the cabinet councils of the greatest republic on earth. Gentlemen, I have the honor to intro-

duce to you the Assistant Secretary of Agriculture, the Hon. Joseph H. Brigham.

Mr. Brigham. Gentlemen of the Weather Bureau and other distinguished citizens: I am very glad to have the privilege of meeting with you here to-night, and to be permitted to say a few words about the Department of Agriculture, a Department that exists to-day because of the earnest efforts, long continued, of farm organizations. I am familiar with every step that was taken for the creation of this Department. The work was done by plain, practical men, not for the purpose of furnishing soft places for politicians, not for the purpose of drawing a certain amount of money from the National Treasury. Their idea and purpose was to help the greatest and most important industry of our country, that of agriculture. They realized that a large per cent of our people must always labor in the field, must be directly connected with agriculture. They believed it to be important to dignify the calling of agriculture; they believed it important to teach the ambitious boy on the farm that there was room for the exercise of all his ability and energy in the field of agriculture; they believed it important to have a representative in the council chamber of the Chief Executive, where suggestions could be made in the interests of this great and indispensable industry, agriculture.

Having this object in view, they labored earnestly for many years to secure their desire. Very few people believed it possible when it was first agitated; even the agricultural press scouted the idea of having a Department of Agriculture. They seemed to think it was class legislation. Farmers did not so consider it; they understood that everybody was interested in cheapening the cost of bread, and that everybody had to rely upon the labor of those who toil in the fields; that when the farmers prosper, there is general prosperity, and that when times are hard on the farm they are hard everywhere. They understood this, and so they labored for the elevation of the Department, and their efforts were crowned with success. Now, it was necessary to have at the head of this Department a man who was in full sympathy with this purpose. I believe we have in the present Secretary of Agriculture a man whose whole soul and all his energy are directed to the purposes that they had in view, namely, of doing some useful work for agriculture. There are a good many people in the world who do not comprehend the importance of this industry. I want to say to you that the crop of a single year, if multiplied by twelve, would pay the national debt of every country in the world—*every country in the world!*—and many nations never expect to pay their debts. Three billion five hundred million dollars was the cash value of the crop of 1897. In the last year, we sent abroad, after supplying our own people, after feeding our own people as no other people in the world are fed, $1,210,000,000 worth of our products. Not all of this came from the farm, but 70 per cent of it was from the farms of our country. Something over $800,000,000 more than we bought from foreign countries have been exported in the last two years. If we can continue that for a few years, and I believe we can, with the able assistance of the Weather Bureau [applause], we may expect to see coming back to our country every bond and obligation held abroad, canceled and paid.

The Weather Bureau is one of the important parts of the Department of Agriculture. Two or three years ago I was invited to outline the work that ought to be accomplished by a department of agriculture, and in giving my ideas, one of the things I emphasized was that the system of crop and weather reporting must be perfected [applause].

Now, gentlemen, there is some scoffing at your work. Occasionally, as Professor Moore has suggested, you make a mistake, and the people never forget that you have made it. They talk a great deal about it, but say very little about the predictions that have proved to be true. But, gentlemen, the great body of the people believe in the Weather Bureau and its reports. The most intelligent farmers in the country rely upon the Weather Bureau reports [applause]. I will give you just a single instance. One of the most intelligent farmers of our country, a resident of the State of New York, cited an instance where the service had been of great value to him. He used to drive to the station every morning to see what the reports were from the Weather Bureau, and he conducted his farming operations in accordance with the report. He said his experience had demonstrated that 80 per cent of the predictions proved true. He went down one morning when the sun was shining brightly and everything indicated the very best conditions for cutting clover hay. Now, hay is one of the most important crops of this country. He had started his mowers before he left home. He found that the Weather Bureau had reported the approach of a storm from the west, and that it would be there about the time his hay was fit to go into the barn. He went back and told his men to stop mowing. They laughed at him; they said it was ideal haying weather. "Never mind, boys," he said, "go and plow corn to-day." He saw his neighbor with three or four machines running, and told him what the Weather Bureau report was, advising him to stop his mowers. "If you take any stock in those Weather Bureau fellows," said his neighbor, "all right; I don't." He kept his mowers going, and he never put a pound of that hay into the barn—but it made good manure! [applause].

All over this country men go out of doors about 1 o'clock or 1:30, and listen for the whistle signal. All over this country your work is appreciated by the farmer—the common every-day farmer—the man who plows, who tills the soil, who garners the crop—he is interested in your work. He believes in you.

So far as the Department of Agriculture is concerned, I am not afraid to say, speaking for the head of the Department as well as myself, that we shall lend you every aid in our power [applause]. We are going to sustain you and see that you are sustained. We are going to smile when you make mistakes [laughter], but we are not going to let the public forget that you hit it "'most every time."

And now we will all cooperate—farmers, Weather Bureau, lawyers, railroad attorneys, representatives of transportation companies, manufacturers—all classes engaged in productive industries—we will cooperate earnestly and intelligently and build up here in the United States the grandest nation that ever existed under the sun! In conclusion, I want to say that our influence for good will not be limited by the shore lines of the Atlantic and Pacific [applause]. This country is strong enough to reach out and help the oppressed

in every portion of the world [applause] and wherever humanity suffers, wherever freedom is longed for and not enjoyed, the strong arm of the United States and the stars and stripes will go together to give the oppressed of all the world the freedom and liberty that we enjoy here in the United States of America! [great applause and cheering].

Professor Moore. Gentlemen: After the forceful and invigorating words of our Assistant Secretary we should pause a moment for reflection. Sure it is that in the councils of the Department he has always stood loyally by the Weather Bureau, believed in it and encouraged its upbuilding. In this connection let me say to you that Secretary Wilson has great affection for this Bureau. He has done more to extend the geographic boundaries of its usefulness than any of his predecessors, and I do not say this to disparage other secretaries, for we have always had able Secretaries of Agriculture. Now, when we talk of building up the Department of Agriculture or the Weather Bureau, we can not do it ourselves. Congress must listen to our plea, must measure our needs and the value of what we propose to do. We have with us to-night a representative of the upper house of Congress. He has never yet failed to lend his influence to increase the usefulness of the Weather Bureau. When we wanted an emergency appropriation to enable us to cover the great West Indies with a twice-daily meteorological survey, he rendered assistance, and his influence is potent, I would have you know. There are few, if any in the halls of Congress, who command more respect; whose voice is more eloquent or whose efforts mean more for the cause he espouses. He stood by us; he assisted us; and we secured the appropriation which enabled us to place in the West Indies a service which to-day, throughout the civilized world, is bringing credit to the United States of America. A great scientist, living at Kingston, Jamaica, ten years ago, visited England for the purpose of laying before the British Government the idea or plan which the United States has to-day established, and which it inaugurated within thirty-five days after the act of Congress providing for the service received the approval of the President. That scientist went to the British Government and presented his plan, stating what he would do if the Government assisted him. He came back, and to Professor Abbe he told his story, returning to his country a broken-hearted man. His whole life had been spent in that work. To-day he lives to see the realization of his project, not, however, put into effect by England but by the United States.

So, gentlemen, we must give an account of ourselves to our national legislators, and they in turn must be accountable to their constituencies.

We have had no more loyal friend than Senator John M. Thurston. I will ask him to respond to the toast "Nebraska Weather."

Senator Thurston. Mr. Toastmaster and Gentlemen of the Weather Bureau: You have made a sad mistake in putting me on this program. This is my home; here I have lived and watched the weather, out and in, for twenty-nine years, and I say it, possibly with regret, but certainly with truth, that my own people are on to my

"isothermal curves" [laughter]. I reserve my speeches for those who are strangers.

I sit to-night an humble disciple at the feet of the Weather Bureau. I came here paralyzed with an awful drought [laughter], and I have absorbed, by your good will, so much humidity that I have no idea what prediction to make for to-morrow [laughter]. Nebraska is in an unfortunate position on the map of the United States. We are surrounded on three sides by dry States [laughter]—Kansas, Iowa, and South Dakota. That, perhaps, is the reason why Omaha is the Mecca for the pilgrimage of the citizens of those States. Our greatest danger comes from hot winds. They strike us generally in campaign conditions. They are popularly supposed to originate with "Cyclone" Davis, Jerry Simpson, and Mary Ellen Lease. When we do not get these hot winds from the south, we get good crops, good times, good government, and good conditions.

It has been a pleasure to me, in common with all our citizens, to welcome you here, and especially at this time. We had set our hearts upon having good weather when the President of the United States came to us [referring to the President's attendance on the occasion of the Peace Jubilee exercises in Omaha, October 12–13], and when I discovered that Professor Moore had assembled you gentlemen in Omaha at the same time I reverently lifted my hands and thanked God, for, I said, we shall have good weather—good weather, and any kind we want. We have had it dry for our visitors from the States that are dry; we have had it wet for every gentleman assembled at this board; we have had it cold upon our streets to-night, but we have it warm here, and hot where the newspaper boys [referring to the Washington correspondents who made the trip with President McKinley] are taking in the midway at the Exposition!

My fellow-citizens, Nebraska is peculiarly dependent upon good weather. Give us good weather, and we can give you everything else. Give us good weather, and we can give you corn enough to feed the world and have enough left over to furnish good whisky for the earth. Give us good weather, and we can furnish all the hogs, in addition to the others among us [laughter], to supply the necessities of the world. But without good weather we are nothing. We suffered under bad weather for two years. That was before you boys got on to your business. Since then there has been no trouble. Under this Weather Bureau and your distinguished Chief we have had good weather; and if the country will keep you all in the Weather Bureau as long as you live, we can feed the world and have loaves and fishes left over.

So far as I stand here to-night to speak for the Congress of the United States, I will say that as long as you give us good predictions we will give you good appropriations [applause]. It was good weather for the people of the United States when William McKinley became President. You gave us good weather for his inauguration day, and I have noticed that your weather, as you give it to us on inauguration day, generally furnishes a good forecast for the success of the administration [applause]. And you have crowned your achievements by giving us good weather when he came among us to honor us with his presence at the great Transmississippi Exposition. This is a good weather administration. You gave us good weather when Dewey steamed into the harbor of Manila. You gave us good weather when Schley and Sampson followed the Spanish fleet along the Cuban coast [applause] and sent them down with greetings to the

Maine. You gave us good weather when the army of the United States, regular and volunteer, Federal and Confederate, black and white, charged up the heights of San Juan [applause]. There is good weather wherever the American flag floats, on land or sea, at home or abroad [applause], for it represents a nation that has uplifted humanity beyond any conception of the dreamers of ancient times. Good weather in this country of ours, as nationally typified, has made us beloved and respected around the globe. Oh! this beautiful land of ours, in which we have good weather from sea to sea, from lake to gulf! This beautiful land of ours! reserved by God Himself that in the fullness of time it might behold a nation destined to stand for the advancement of humanity and all that is best in it. The ancients believed in an Arcadian realm toward which those happy mortals, favored of the gods might sail on summer seas; and where the sun-kissed ocean waves washed its shores they saw its golden strand. This is that land. The centuries have given it to the human race that on its peaceful shores earth's toiling millions might find hope and rest; have given it that those oppressed in other climes might here be free; have given it that its sheltering valleys might abound in pleasant homes, and its eternal hilltops glorify the goodness of Almighty God. [great applause and cheering].

Professor Moore. Gentlemen: We have enjoyed the eloquent words of this distinguished Senator. Before I introduce the next speaker, however, to respond to the toast "The Press and the Weather Bureau," I will tell you a little incident illustrating the somewhat humorous side of the relationship between the Weather Bureau and the press, or rather of the press to the Weather Bureau.

Some years ago a forecaster of the Weather Bureau, who was receiving eighteen hundred dollars a year, attempted to live in his community at about a five-thousand dollar pace. There may be others trying to travel the same road, but if we catch them at it we will make short work of them. This individual kept a trotting horse, neglected his family, failed to pay his debts, and in other ways brought discredit upon himself and the service. He was accustomed to make his predictions for a very important State on the coast from a back room in a beer garden, without ever seeing the weather chart. Finally, the Central Office began to verify this official's work, and finding it did not agree at all with the meteorological charts, an investigation was instituted which resulted in his summary dismissal in disgrace from the public service. The next day his hat and coat were found on the beach, and it was assumed that the ex-Weather Bureau official had committed suicide. So a prominent paper came out the next morning with a large picture on the front page, in which was depicted a scene in Hell. At one side sat his Satanic Majesty on a throne of chilled steel. A great retinue of servants and followers were around him, and in front was an immense thermometer which apparently towered into the clouds; and his Satanic Majesty had apparently issued an order for the fire brigade to read the thermometer, for you could see an extension ladder running up the side of the thermometer and a whole troop of devils climbing to the top and endeavoring to read the instrument. It seemed to be "a hot time in the old town" that night. As you still further interpreted this picture, you noticed that a coal hole right

in the middle had been opened, and that coal hole was belching forth fire and smoke from the furnace beneath. In the furnace appeared the head and shoulders of our late lamented forecast official. In his left hand he held a sheet of asbestos, and in his right a piece of charcoal, and he had just written a forecast of a cold wave for "Hell and vicinity." Now, here is where the unfeeling, unsympathetic editor wreaked vengeance on the Weather Bureau. He said: "P. S.—This forecast of a cold wave for Hell and vicinity is just as likely to be verified as were any of those made by the deceased for this city."

Now, gentlemen, the press is a most important factor in the work of the Weather Bureau. How could we reach the great public without the dissemination of our information through the press? It has been my experience, for many years, that the press is inclined to be a little more than fair with the officials of the Weather Bureau. It is inclined to be a little more than fair with every public official. There may be isolated exceptions, but a man should not be too sensitive to criticism. Every public official should feel that it is legitimate for the newspapers to criticise his public actions. It is by that criticism that the public service is improved and the public welfare conserved. I would say to you, without digressing too much, that you should not take offense when the newspapers of your vicinity have a little fun with you.

Gentlemen, we have with us to-night one of the most distinguished editors of the United States—a man who has made his power for good and his influence for purity in public life and for honesty in the administration of public office felt throughout the length and breadth of this land. I never saw him until about six weeks ago when he came to Washington to assist in arranging for this grand Peace Jubilee, but I knew him, and we all knew him by reputation. I have the pleasure of introducing to you the Hon. Edward Rosewater, editor of the Omaha Bee.

Mr. Rosewater. Mr. Toastmaster and Gentlemen of the Weather Bureau: It was perhaps a rather singular freak on the part of your toastmaster to ask me to turn the searchlight of publicity on the weather service and the Weather Bureau, and I realize that the men who deal in futures in that Bureau will feel a little perplexed as to what is coming. Before we enter into a discussion of futures, however, let me digress a little bit to the past. I was the first Weather Bureau observer west of the Missouri River [applause]. Away back in '63 I was requested by Professor Henry of the Smithsonian, when I became located here at Omaha, to make a report from time to time on the weather conditions between Omaha and Salt Lake City. Well, there is nothing remarkable in that, particularly, for I was manager of the Pacific Telegraph [applause] and I had observations made and recorded every day at Omaha, at Julesburg, at Fort Laramie, Fort Bridger, and Salt Lake City; and these were telegraphically reported at given hours, three times a day, and recorded in a book which I kept, right here in Omaha.

Let me digress a little further, perhaps, and give you some facts regarding the foundation of your Bureau. The Weather Bureau, was, of course, the offspring of the Signal Service and the Signal Service was the offspring of the War of the Rebellion. During that war the

Signal Service was organized as an auxiliary of the United States Army Telegraph Corps, of which I was a member. General Myer, after the close of the war, followed the idea out, and with the assistance of the Western Union Telegraph Company, which had a vested right and interest in getting the several million dollars out of this business into a few hands [applause], we promoted this work and extended it away across the plains, down into New Mexico and beyond the Rockies. It may further interest you to know that in those days a 10-word message from Omaha to New York was $5.60 and 30 cents for each additional word, and a message from Omaha to Chicago (I had no conscience, because I was working for the service) was $3.55 for ten words and 24 cents each additional word. So, also, our blessings, as we went farther west, increased in proportion to the distance. From Omaha to Denver, a little over five hundred miles, was something over five dollars. It was a rather profitable business we were all engaged in in the Weather Bureau. We used to let nobody send even a death message until we had ticked off the weather.

You see these observations reach away back. Solomon said: "He that observeth the wind shall not sow, and he that regardeth the clouds shall not reap." So of course this is a very old thing, this Weather Bureau business [laughter]. I thought I was the first, but I guess Solomon was. [laughter].

Now, as to the press and the Weather Bureau. We don't always agree very well. Sometimes we say things you didn't intend us to publish [applause]. Your observers are so sensitive, more so than the barometer, and when we say anything at all, their temperature goes up and they finally rise in their wrath and become intemperate. There is the little clashing that occasionally will happen in the best regulated families, but the press tries to second the efforts of the Weather Bureau and gives you "top of column, next to reading matter," but for all that we are not appreciated—not at all. The people will insist that we are like the weather prophets, that we sometimes will misrepresent things; but they are, as it were, coupling us with the Weather Bureau, and our reputations being so closely linked together, they sometimes think we are both faking. I want to assure you that we publish the papers nevertheless, and publish at the top of the column above all things, the forecast for the next day. We will continue to do it as long as you are willing to continue to draw your salaries.

Now, it is getting late, and I know there is such a thing as brevity in wit, such a thing as having enough of a good thing. I want to assure you, as Colonel Brigham did as regards the Department, that you can always depend upon us for our support; we will all stand by you. Of course I am only one of the representatives of the press, and we do not always agree. But when you make your next observations, I hope you will conclude that the press is your friend.

Professor Moore. Mr. Rosewater has just referred to the work of pioneer meteorological observers. It gives me pleasure to introduce as the next speaker a representative of the Smithsonian Institution, which turned over to the Army Signal Service its system of voluntary meteorological stations upon the establishment by law of that service in 1870. Dr. Marcus Benjamin of the Smithsonian Institution will now address you.

Dr. Benjamin. I am very glad to avail myself of the opportunity of saying a few words concerning the beginning of systematic work in meteorology by the Smithsonian Institution.

It is just a little more than a half century since the Smithsonian Institution came into formal existence, and at that time the beginnings of the science of meteorology were apparent. The brilliant genius of Espy was making itself felt in various parts of the country; the patient Loomis was considering the subject in his careful way; and Redfield, more practical than the others, saw commercial benefits to be derived by collecting data about the weather. It is true, however, that even before this, the regular accumulation of meteorological observations had been undertaken from time to time under the direction of the War Department and also by the Navy Department, but they had not been persistent.

Professor Henry, the first Secretary of the Smithsonian Institution, in looking about for subjects with which to carry out in the best possible manner the wishes of the founder of the new institution established for the purpose of increasing and diffusing knowledge, was quick to recognize the value of giving information to the public in regard to the weather. Men of science from many localities throughout the country were invited to cooperate by making meteorological observations. These were sent to Washington and there placed in the hands of Professor Coffin, of Easton, who undertook their computation. The aid of the various telegraph companies was solicited and obtained. A large map was set up in one of the halls of the Smithsonian building, and every day, at a certain hour, facts of the weather as received were indicated on this map by means of suitable markers. In this way the first daily weather map came into existence. With the Civil War came a partial interruption of the work, chiefly in consequence of the extraordinary demands on the telegraphic service. After the war the transfer of the work to the War Department took place, and later it passed to the charge of the Department of Agriculture. But interest in meteorology did not cease in the Smithsonian Institution with the transfers just mentioned. Our present Secretary, Dr. Langley, realizing that the time must soon come when present means of transportation would be inadequate, has devoted much of his thought to studies connected with the problem of aerial navigation, and among these none has received greater recognition than those that pertain to the force of the winds.

Before taking my seat I want to say that some of us have grown to believe a good deal in Civil Service, and if, as certain of our politicians and newspapers would have us believe, that system of promotion by merit should be abolished, then I would observe that when that time comes, it will be impossible to secure for public office men who have risen from the ranks such as the present Chief of the Weather Bureau. We believe that he is a splendid illustration of the right man in the right place, and his fitness for his present appointment is the result of having demonstrated his capacity in subordinate affairs.

Professor Moore. Just at this point, there is one matter to which I wish to refer, and that is the magnificent nonpartisanship of the present Secretary of Agriculture. In recommending and securing from

Congress legislation to extend the weather service into the arid and subarid regions of the West, into the cotton regions of the South, and into the West Indies, there has been no sectionalism in his policy. He is a Republican Secretary of Agriculture, and every one of those additional stations, except one, has gone into Democratic States. This is not a political Bureau [applause]. I say this without any disparagement to politics, because I believe there is not a man now looking into my face who does not value the elective franchise that is given to every citizen in America, and who will not freely and impartially exercise that franchise. But in extending the benefits of the weather service, the present Secretary of Agriculture, the Honorable James Wilson, and his assistant, Colonel Brigham, who presides in his absence, recognize that the weather service is here to serve all interests, without regard to politics. Gentlemen here have paid me several compliments as the Chief of this greatest of all meteorological services, but I want to say to them that my power is derived entirely from the Secretary of Agriculture and his assistant, and without their support I could not hold my office a minute. The credit for the work we are doing to-day belongs to them, I am simply their executive.

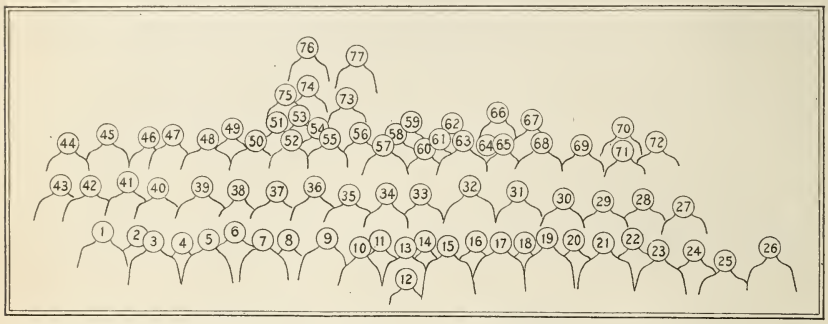
ERRATUM.

In the fifth line of the first paragraph on page 173, "Hon. William Pitt Kellogg" should read "Hon. Stephen B. Packard."

KEY TO ILLUSTRATION.

With this report is given a half-tone reproduction of a photograph of seventy-seven persons attending the Convention whose names appear in the list below.

By means of the accompanying diagram, and numbers and names in the list, the name of each person in the group (except number 33, believed to be a newspaper reporter) can be ascertained.



1 F. H. Brandenburg.
2 J. Warren Smith.
3 T. F. Townsend.
4 S. W. Glenn.
5 James Berry.
6 H. C. Bate.
7 I. M. Cline.
8 L. M. Pindell.
9 Prof. H. A. Hazen.
10 Prof. C. Abbe.
11 J. B. Marbury.
12 James Berry, Jr.
13 E. B. Calvert.
14 G. H. Noyes.
15 Prof. W. L. Moore.
16 S. C. Emery.
17 H. J. Cox.
18 P. F. Lyons.
19 W. H. Hammon.
20 G. B. Wurtz.
21 E. A. Beals.
22 Patrick Connor.
23 A. F. Sims.
24 R. L. Anderson.
25 J. C. Piercy.
26 B. B. Smith.
27 R. M. Reese.
28 G. T. Todd.
29 C. E. Linney.
30 C. N. Butt.
31 J. Knappenburg.
32 Wayland Bailey.
33
34 D. Cuthbertson.
35 C. F. R. Wappenhans.
36 T. S. Outram.
37 G. M. Chappel.
38 C. F. Schneider.
39 N. B. Conger.
40 J. W. Bauer.
41 E. W. McGann.
42 H. H. Curley.
43 G. Hass-Hagen.
44 W. M. Fulton.
45 R. J. Hyatt.
46 P. H. Boothroyd.
47 Martin Musil.
48 Elvin J. Glass.
49 J. R. Sage.
50 Dr. J. W. Kales.
51 G. C. Kaesmacher.
52 B. H. Bronson.
53 A. E. Hackett.
54 J. J. Conrad.
55 J. H. Spencer.
56 J. P. Slaughter.
57 P. H. Smyth.
58 Frank P. Chaffee.
59 W. S. Palmer.
60 U. G. Purssell.
61 J. M. Sherier.
62 R. G. Allen.
63 W. M. Wilson.
64 F. J. Walz.
65 E. H. Bowie.
66 John W. Smith.
67 John Craig.
68 G. A. Perley.
69 E. B. Richards.
70 M. H. Pierce.
71 G. N. Salisbury.
72 A. S. Van Sandt.
73 Nathan W. Blanchard.
74 A. J. Mitchell.
75 Miss Ruth Mitchell.
76 M. B. Light.
77 T. B. Jennings.